Proceedings of the twentieth oilseed processing clinic

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SOUTHERN MARKETING
AND NUTRITION
RESEARCH DIVISION

AGRICULTURAL RESEARCH SERVICE • U.S. DEPARTMENT OF AGRICULTURE

PREFACE

The Oilseed Processing Clinic is sponsored jointly by the Southern Marketing and Nutrition Research Division and the Mississippi Valley Oilseed Processors Association, Inc.

The presentations at this Clinic reported changes that have occurred in the industry within the past 20 years, the need for additional research studies, the outlook for oilseeds, new cottonseed products, good manufacturing practices, and a review of the aflatoxin problem.

These proceedings report the statements presented by the various speakers during the 1971 Clinic.

C. H. FISHER, Director
Southern Marketing and Nutrition
Research Division

DEDICATION

This Conference is dedicated to:

A. Cecil Wamble: for his outstanding contribution through research to the success of the oilseed industry.

Porter A. Williams: for his leadership and practical application of research developments to the processing of oilseeds.

We are proud and honored to have been associated with these outstanding industry leaders.

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The opinions expressed by the participants appearing at this conference are their own and do not necessarily represent the view of the U. S. Department of Agriculture.

Numbers in parentheses refer to references at the end of each paper. The data presented in the references, figures, and tables are reproduced essentially as they were supplied by the author of each paper.

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WELCOME

by
C. H. Fisher, Director
Southern Marketing and Nutrition Research Division
New Orleans, La.

On behalf of the Southern Marketing and Nutrition Research Division, I welcome you to the 20th Oilseed Processing Clinic. I hope you will find this meeting so worthwhile that you will return again and again until we can count you among our old friends.

I welcome you also on behalf of George W. Irving, Administrator of the Agricultural Research Service, and Talcott W. Edminster, our new Associate Administrator. They have asked me to give you their greetings and best wishes for a successful conference.

I extend special greetings to Jerry H. Jeffery, President of the Mississippi Valley Oilseed Processors' Association, F. R. Senti, Deputy Administrator of Marketing and Nutrition Research; and J. Dukes Wooters, Jr., Executive Vice President and General Manager of Cotton Incorporated (formerly the Cotton Producers Institute).

I wish to call your attention to the fact that our Division's name has been changed — what was formerly the Southern Utilization Research and Development Division is now the Southern Marketing and Nutrition Research Division. The names of the other utilization divisions have been changed similarly. Our installation here at New Orleans, however, remains as the Southern Regional Research Laboratory. Our goal remains the same, too. We are continuing our efforts to serve agriculture, industry, and the consumer to the best of our ability.

No doubt you have noticed another change — instead of the Cottonseed Processing Clinic, we now have the Oilseed Processing Clinic. This is because of the growing importance of soybeans and other oilseeds in the South.

Despite the name change, this is still the same Processing Clinic — and a very special one, because it marks 20 years since Clarence Garner, Ed Gastrock, Allen Smith, Mac Verdery, Ralph Woodruff, and other representatives of the Mississippi Valley Oilseed Processors Association (MVOPA) and the Southern Marketing and Nutrition Research Division got together for that first Processing Clinic.

Regretfully, some of the people who contributed greatly to the success of these meetings in former years are no longer with us. This year's clinic is respectfully dedicated to two of these men — Cecil Wamble, for many years head of the Cottonseed Products Research Laboratory at Texas A&M, and Porter A. Williams, an executive with Hunt-Wesson.

Besides being the 20th anniversary of the Cottonseed Processing Clinic, this year also marks the 30th anniversary of the Southern Marketing and Nutrition Research Division. Our research on oilseeds began in 1941 and this anniversary seems an appropriate time to recall some of the accomplishments of the past 30 years. SMNRD has described its research findings in about 4,300 papers and in more than 500 patents. We think that the new information in these nearly 5,000 publications has been and will be highly beneficial. We could not have advanced so far in achieving our research goals without the wholehearted and enthusiastic cooperation we have received from industrial and other organizations.

OPENING REMARKS

by
Jerry H. Jeffery
The Southern Cotton Oil Co., Inc.
Newport, Ark.

On behalf of the Mississippi Valley Oilseed Processors Association, I want to express my appreciation for your attendance here today.

A tremendous amount of time and effort has been given by those responsible for the program of this clinic.

I especially want to thank Dr. Fisher, Dr. Wojcik, the competent staff at the Southern Regional Research Laboratory, and our own Tom Allen, who has contributed so much over the years.

EFFORTS, ACHIEVEMENTS, AND FUTURE OF ARS OILSEED RESEARCH

by
Frederic R. Senti
Deputy Administrator, Marketing and Nutrition Research Division
Agricultural Research Service
U.S. Department of Agriculture
Washington, D. C.

When statistics are cited about the economic importance of agricultural products, we usually hear about the tremendous volume and the enormous dollar values of wheat, corn, and cotton. Figures on the volume and cash value of fats and oils, and of the oilseed crops, are heard much less frequently, and then usually in terms of the single commodity under discussion.

The fact is that the oilseed crops have been increasing at a phenomenal rate in acreage planted, in volume, and in cash returns. In the period from 1940 to 1969 (which, incidentally, is also the period USDA's regional research laboratories have been in operation) the acreage planted to oil-bearing crops increased from 42,894[1] million acres to 56,631[2] million, an increase of 32 percent. In that same period production increased by 330 percent, from 9,397[1] thousand tons to 40,416[2] thousand tons. Farm value rose from \$288,795,000[1] in 1940 to \$3,240,735,000[2] in 1969, measured in current dollars, an increase of 1,022 percent. Even in terms of 1940 dollars, the increase is impressive, from \$288,795,000 in 1940 to \$1,239,760,000 in 1969. These figures include castor, cottonseed, flaxseed, mustard seed, peanuts, safflower, soybeans, sunflower, and tung.

I mention these figures to emphasize the importance of the commodities with which we are dealing, but I will limit my comments to research conducted in that part of Agriculture Research Service for which I have responsibility. This is marketing and nutrition research, which broadly stated, covers research dealing with the transportation, handling, storage, processing, product development, and nutritional value of agricultural commodities. This work is conducted in nine ARS research divisions. Five of these are the utilization research divisions, headquartered at the five large regional research laboratories, of which the Southern Regional Research Laboratory is one. The other four are the Market Quality, Transportation and Facilities, Human Nutrition, and Consumer and Food Economics Research Divisions.

I will also give a complete coverage of our past research, in that it includes research efforts as well as achievements. I presume that the distinction between effort and achievement is that achievements have come from efforts that resulted in findings which have been put into commercial use and not that efforts represent research that did not achieve an intended objective. However it was intended, I can give you only a broad overview of our program and include a few selected examples of the research that we have done or are currently engaged in, and the problems and opportunities we see for future oilseed research.

The processing and utilization of oilseeds has been an important part of the program for the Regional Research Laboratories ever since they were established. These laboratories and our other research divisions have made some valuable contributions to the growth of the oilseed industry, although we would not presume to take full credit for its amazing growth. This must be attributed to several factors, including the changing needs and demands of our times, and the enterprising and progressive attitudes of the oilseed industry as well as private, state, and federal research.

Oilseeds, like other commodities, were assigned to the laboratories according to region. The Southern Regional Research Laboratory works on cottonseed and peanuts; Northern, on soybeans, flaxseed, erucic acid-containing oilseeds, and new oilseed crops; Western, on castor, safflower, and other western seed oils; and the Southeastern on sunflower seed.

The objective of our utilization research has been to develop information on the chemical composition and properties of oilseeds and the physical, chemical, and biochemical properties of their constituents, and further, to develop processes for the separation or conversion of the constituents into more useful forms, whereby each oilseed can be used to its maximum extent in food, feed, or industrial products.

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[1]Compiled from "U.S. Fats and Oils Statistics, 1909-65, "Statistical Bull. 376, USDA, ERS, Washington, D.C., Aug. 1966; and "1959 Census of Agriculture," Vol. II, General Report, Statistics by Subjects, U.S. Bureau of Census.

[2]Compiled from FAS Series on Foreign Fats and Oils, various "PVO Market Letters," and various Fats and Oils Situations.

The oils of two of the crops mentioned above — flaxseed and castor — are produced exclusively for nonfood uses. Crambe, a new oilseed crop, also produces an industrial oil. Oils of the remaining crops go primarily into edible products, but a significant part of their production enters industrial markets.

The beginning of our research on the utilization of vegetable oils in 1940 was in a period of increasing industrial research on synthetic polymeric materials designed to emulate and replace natural products of agricultural origin in many of their major industrial uses. During the ensuing years, the synthetics have been tailored with properties to serve as resins, adhesives, varnishes, paint vehicles, and a variety of other applications once served exclusively by vegetable oils or other materials of plant origin.

The challenge in our research has been to meet this competition, and this we have endeavored to do by developing information on the physical properties and chemical reactions of the vegetable oils as a basis for development of new and improved industrial products, both in our laboratories and in those of industry. A large amount of such information has been developed in the past three decades of research. This has been made available to the industry in the form of publications in technical journals, as patents, and in presentation at scientific meetings. At SMNRD alone, for example, over 850 papers have been published, and 95 patents have been granted which deal with cottonseed or peanuts.

The extent to which this information on vegetable oils has been applied in industry is difficult to estimate. Some of our patents are licensed, but we know that others may be practiced without application for license. Other information that we have published on processing, properties, and new products from vegetable oils, but not covered with patents, has also been applied in industry, either as such or as a starting point for further development.

I should take this opportunity to tell you that the Department's patent policy was recently changed. Formerly, we could grant only nonexclusive licenses for the practice of our patents. Under certain conditions we now can grant limited exclusive licenses to our inventions that are covered by a patent or a patent application. Limited refers principally to the period of exclusivity, which will nominally be 5 years, but which is expected to be sufficient to enable the license to recover development costs. A list of the first group of patents available for exclusive license will soon be published in the Federal Register.

Linseed oil. An example of industrial product development that has come from our research on linseed oil is the development of stable water emulsions of linseed oil. Original impetus for this work was the introduction of synthetic emulsion paints into the exterior paint market, a market once held almost exclusively by linseed oil because of its superior drying and film-forming properties. Advantages of the emulsion paints were greater ease of application, less odor, and easier cleaning of application equipment. Linseed-oil emulsion paints were successfully formulated which provided the handling and applying properties of synthetic emulsion paints, were successfully formulated and produced commercially. Currently, linseed oil emulsion is used in combination with synthetic polymers in many exterior latex paints, because of the improved adhesion it imparts to the paint film.

A broad new area of use for linseed oil opened about 10 years ago. This was its application as a coating on concrete highways to protect them against the spalling action of salt, which has found increasing use in the past 10 years to keep highways and streets free from ice in winter. Our Northern Laboratory has worked in cooperation with the linseed oil industry, to demonstrate the value of linseed oil in the presence of salt solutions. The linseed oil is applied from solution in mineral spirits to increase greatly the number of freeze-thaw cycles that concrete will endure without scaling damage.

Another new use for linseed oil now being developed is a curing agent. When applied to freshly laid concrete, it retains sufficient water for normal curing. There are now commercial curing compounds used for this purpose, but the linseed oil emulsion developed in our research has the added advantage that it apparently protects the concrete from subsequent deterioration in winter on exposure to freeze-thaw cycles and deicing chemicals. This emulsion has been used successfully on a commercial scale for curing and protecting concrete in Kansas, Oklahoma, and Texas. Four companies are now manufacturing the emulsion.

Castor oil. In our research on castor oil, we have endeavored to take advantage of its unique chemical structure; 90 percent of the total fatty acids in castor is ricinoleic acid, containing both unsaturated and hydroxyl groups. A considerable ARS research effort in cooperation with industry has taken advantage of this chemical structure in the production of rigid polyurethane foams that are fireproof and that have good thermal-insulating properties. Market demand for urethane-foam products from all sources is projected to double by 1975, reaching a level of nearly 2 billion pounds per year (C&E News, Jan. 25, 1971).

Another application for castor oil in which commercial practice has developed concurrently

with our research has been in elastomeric-potting compounds for electrical equipment. Shock resistance and impact absorption are critical in this application and castor-derived urethanes show much better shock resistance than similar formulations from petroleum products.

An area of our research on castor which is likely to become increasingly important to the castor industry is the development of processing treatments for the pomace or meal. Purpose of these treatments is inactivation of the toxic and allergenic components that limit use of the meal as an animal feed. The principal toxic component, ricin, can be destroyed by heat when moisture content is above 15 percent. Allergenic fractions are more difficult to inactivate. Treatments for their destruction have been developed at our Western Regional Research Laboratory by use of lime, ammonia, or steam. Since handling of untreated castor meal poses a health problem, our processes for detoxification should soon be supplemented by commercial use of the deallergenization procedures.

Soybean oil. As mentioned earlier, soybean oil finds its major use in edible products. Its large production encourages research on the development of additional outlets in nonfood uses. Several such applications have come from ARS research. Epoxidized soybean oil, produced by a reaction originally discovered at our Eastern Regional Research Laboratory in research on animal fats, finds wide use as a plasticizer in polyvinyl chloride plastics. Other research findings have been commercialized through use of soybean oil in paints and varnishes, polyamide resins for coatings, dimer acids in alkyd resins, and in polyethers.

Research for the future. Relative to the future of oilseeds in the industrial product field, there continue to be possibilities for new industrial products from vegetable oils through further development and applications research. The demand for plastics, plasticizers, adhesives, detergents, and like organic materials continues to grow. To compete in this market with petrochemicals, the vegetable oil chemist must gain advantage from the chemical structures which nature has built into these oils. This is no easy task, but our chemists now have under investigation several new chemical reactions and oil derivatives that hold promise for future development.

EDIBLE OIL RESEARCH

Food products constitute by far the largest outlet for vegetable oils, and this market has expanded greatly in the past three decades. To a considerable extent, the different vegetable oils are interchangeable as ingredients in the shortenings, margarines, cooking and salad oils that constitute the edible oil and fat market. This interchangeability has come from research on oil extraction and refining, hydrogenation, and other aspects of margarine and shortening manufacture, and on factors important to the stability of salad and cooking oils. Despite this interchangeability, superior properties, either physical or compositional, for some uses are still possessed by individual vegetable oils.

Soybean oil. Improvements in soybean oil properties from research have been an important factor in the acceptance and marked growth in consumption of this oil in food products in recent years. ARS research at our Northern Laboratory has made important contributions to soybean oil technology — by demonstrating that extremely small amounts of trace metals, especially iron and copper, cause off-flavors; by showing that addition of inactivators, e.g. citric acid, to the oil can largely overcome the effects of trace metals; and by developing techniques for process and quality control and for evaluating research results on oil quality, based on judgments of a trained taste panel. Contributions have been made by showing through basic research that the linolenic acid component of soybean oil is the major precursor of off-flavors; by developing methods for determining fatty acids and their distribution in glyceride oils; by determining the rate and mechanism of hydrogenation of unsaturated fatty acids; and by developing selective hydrogenation catalysts, as well as through a number of other research findings.

Cottonseed oil. Our research on cottonseed oil has been concerned through the years with many aspects of processing, with improvement of edible and industrial oil products, and with development of new products.

Improved methods have been developed for bleaching cottonseed oil. A high-shear refining process for removing color bodies from difficult-to-refine oils has been adopted by industry.

In another phase of processing research, the discovery was made that semisolid or plastic fats can be tempered or put into their most stable crystal form very rapidly by intense mechanical working. This discovery has been adopted by the confectionery industry and, more recently, the principle of tempering by intense mechanical working in the manufacture of shortening. This principle makes possible streamlining of the manufacturing process possible and eliminates the need for special, temperature-controlled warehouses, in which formerly the fat products had to be stored several days before shipment.

New, edible products from cottonseed oil have received attention through the years. The acetoglycerides developed at the Southern

Laboratory were commercialized a number of years ago. The acetoglycerides comprise a family of unusual fat products that can be used as emulsifiers, as edible lubricants on machinery that touches food, and as protective food coatings to retard moisture transmission and increase shelf life.

A new process has been developed at our Southern Laboratory for making sucrose esters (emulsifiers made from sugar and fats) without solvents. The presence of residual solvents in sucrose esters made by the current commercial process is considered undesirable for food use.

New oilseed crops. Research is now in progress on two essentially new oilseed crops of particular interest to the southern and western regions of this country. In the first, a sunflower program has been initiated at our Southeastern Marketing and Nutrition Research Division at Athens, Ga.; in the second, the high, oleic acid varieties of safflower are being researched at our Western Division. In both cases, close cooperation exists with the plant breeders in determining the composition of these new oils, evaluating them for properties important to food applications, and investigating their processing properties.

SOME COMMENTS ON RESEARCH FOR THE FUTURE

How important future production of sunflower and high-oleic safflower will be is difficult to estimate. Much will depend on the yield and other agronomic improvements that may be made, as well as on the properties of their oils and meals, and the demand for these products. We might expect high-oil crops such as these to be in an advantageous position if high-lysine, high-protein corn becomes available, and if demand for protein supplements in livestock rations were thereby decreased. Regardless of this possibility, we believe continued research on these crops is merited because of the contribution they can make in the current demand situation.

Because of the increasing demand for soybeans in both domestic and export markets as a source of protein concentrate for animal feed, we consider it important that the properties of soybean oil should be no deterrent in marketing soybeans to satisfy this increased demand. To this end, our research effort will continue to emphasize processes to improve the oxidative and thermal stability of soybean oil, particularly as salad and cooking oil, an increasing market for vegetable oils.

An interesting point in connection with the research on soybean oil stability is that the selective hydrogenation catalysts developed for this purpose has been used experimentally to prepare flavor-stable cooking oils from linseed oil. Interest in this work stems from the current relatively low price of linseed oil, and again emphasizes the interchangeability of oils that technology can achieve. Needless to say, future research will depend largely on the projection of the relative price level of linseed oil, as well as on further development of technology.

Another aspect of edible-oil research for the future relates to the role of fat in the human diet and its relationship to health. The recent Report of the Inter-Society Commission for Heart Disease Resources on the Primary Prevention of Atherosclerotic Diseases makes two points with respect to fat in the diet. One is that less than 35 percent of total calories in the diet should come from fats. The other is that for most people, saturated fats should constitute less than 10 percent of total calories.

Implementation of such recommendations would have major impact on fat consumption. About 40 to 42 percent of calories now in the U.S. diet comes from fat, and reduction to the 35-percent level would mean a 12- to 15-percent decrease in fat consumption. Primary impact would be on products high in saturated fats as, for example, animal fats. Their reduction would lower both total calories from fat and the proportion of saturates in the diet. One can speculate on what might be done to reduce the fat in dairy products — milk, cheese, ice cream, etc.

One approach would be to replace the butterfat with vegetable oil. Considerable technology in the formulation of these products already exists. Another approach may be to introduce unsaturated fat into the milk and meat via the feed fed to the cow. The problem is to prevent the rumen micro-organisms from hydrogenating the fat. This might be achieved through appropriate protection of the fat by encapsulation or other techniques. There is now some published evidence that such protection can be effected.

There is still controversy on the relation of dietary fat to heart disease, and evidence for the recommended dietary change has not been obtained in controlled population studies. Nor has the implications of the proposed modification of fat intake on the intake of other nutrients that accompany or replace fat been thoroughly considered. Nonetheless, the implications of such proposed dietary changes in relation to research in the fats and oils industries become readily apparent.

There are other fatty acid components of vegetable oils and vegetable oil products about which questions of physiological activity may be raised. Malvalic acid in cottonseed oil is an example. This acid occurs at a level of about 1 percent in crude cottonseed oil and causes pink

egg whites in eggs from hens fed cottonseed meal containing residual oil. It causes other physiological disorders as well. Simple methods have, however, been developed at the Southern Laboratory for transforming malvalic acid to an inactive form, and I think a control measure is available for any potential problems from this source.

The recent adverse findings in animal-feeding experiments with rapeseed oil, which are attributed to the erucic acid component of the oil, raises the question of the so-called unnatural isomers known to be present in hydrogenated vegetable oils. Whether the activity of erucic acid results from its unusual chain length, or from the position of its double bond (both of which differ from the major fatty acids in commercial vegetable oils) has not been reported.

In partial hydrogenation of vegetable oils, however, it is known that there is a migration of double bonds, and a change of configuration about them, to form structures or isomers not present in the natural oil. It can be asked whether these "unnatural" isomers are metabolized in the same way as natural fatty acids, and whether they may have undersirable physiological activity. We are now supporting research on the effect of some of these structural changes on the reaction of the isomeric fatty acids with enzymes. Possibly these studies will provide a clue to changes which might be expected in the metabolism of these fatty acids in the animal body.

Oilseed meal products. The major market for oilseed meals is as protein concentrates in poultry and livestock feeds. Consequently, any oilseed processed in substantial quantity should, for maximum economic return, give a meal that meets the requirements of the feed market. These requirements are more stringent for poultry and swine than for ruminants, particularly as they relate to amino acid balance, fiber content, and inactivation of antinutritional or toxic factors. The largest market can be realized if requirements of monogastrics are met, and this is currently an area of research for several oilseeds.

Another market for oilseed meals is in human foods. Requirements for this market are more demanding than those for feeds for monogastric animals, since not only must nutritional requirements be met, but additional requirements for color, flavor, and functional properties are imposed. Presently, the food market for oilseed protein products is small compared to feed markets. It has been estimated at about 250 million pounds per year. This, however, is a growing market and promises rapid expansion, as sophisticated products, combining economy and functional properties, are developed.

ARS research has developed extensive information on the composition of the oilseed meals, on fractionation processes for separation of the seed components, and on the effect of processing treatments on the physical and chemical changes in components, both as related to inactivation of undesirable components and to loss of nutrients or desirable functional properties.

Our work on processes for the detoxification and inactivation of allergens in castor meal was mentioned earlier. These processing treatments will become increasingly important to castor, as production increases and feed markets are broadened.

Research at the Southern Division contributed to extension of the market for cottonseed meal from its traditional market for ruminants to include new markets in swine and poultry rations. Key factor in the development of these improved cottonseed meals was the research which demonstrated the antinutritional properties of free gossypol and also showed that gossypol reacts with the essential amino acid, lysine, in cottonseed protein during processing, a reaction which must be minimized if high-quality meal is to be produced.

Available lysine was shown to be closely correlated with the nutritive quality of protein. An analytical procedure for available lysine is useful as a chemical index of processing damage.

Solvent extraction processes were devised which remove gossypol from cottonseed, yet preserve the high quality of the protein and have the added advantage of simultaneously extracting aflatoxin that might be present.

Recently, processes have been developed for preparing essentially gossypol free, high-protein flours from cottonseed meal through the mechanical separation of the intact gossypol glands and concentration of the intact protein bodies of the seed by differential contrifugation of the finely divided meal, either in a solvent or in air.

These new flours are useful as protein ingredients in many food products and have opened the way for cottonseed in the new and expanding vegetable protein food market. In addition to direct food use of the flour, these flours provide a starting point for the preparation of protein isolates that have been found to have unusual properties which recommend them for specific food applications.

The liquid-cyclone process, as the centrifugal separation process is called, has been operated on a pilot-plant scale in our Southern Laboratory. The Dorr-Oliver Company has installed a pilot plant in Hubli, India, where it is operating for a second season and is reported to be producing meals with low, free-gossypol content.

Installation of a liquid-cyclone plant with a capacity of 25 tons of cottonseed flour per day is being considered by Plains Cooperative Oil Mill, Lubbock, Tex.

Soybean protein products. Research at our Northern Laboratory on soybean meal was first concerned with improving its value as livestock feed, and noteworthy contributions were made. In recent years, emphasis has been on food uses, and attention has been directed to identification and elimination of components that influence flavor and acceptability of soybean protein products, as well as factors of physiological significance, such as those that produce flatus.

The Northern Laboratory has made significant contributions to the export market for soybeans by demonstrating the quality of U.S. varieties in preparing traditional Oriental foods. Engineering studies have resulted in the development of processes for full-fat soy flour for both domestic and export markets. Northern Laboratory scientists have made a number of contributions to the success of CSM, a high-protein food supplement composed of corn meal (C), soy flour (S), and milk solids (M), which has been purchased by the U.S. Government at the rate of 300 million pounds per year for distribution under the Food for Peace Program.

Peanuts. Basic research at the Southern Marketing and Nutrition Research Division on peanuts has revealed that starches, proteins, and oil are largely segregated in individual packages within the kernel. This information is applicable to other oilseeds, and has been used in the development of some of the most promising processes for the preparation of high-quality cottonseed flours and protein concentrates and isolates. Several years ago, a process was found for the preparation of a light-colored protein from peanuts. This has potential value for producing a food supplement in developing countries where large quantities of peanuts are grown.

Peanut butter is the biggest outlet for peanuts in this country, and has been for many years, but the manufacture of peanut butter was a hit-or-miss operation until research at the Southern Division established optimum procedures for its production.

One of the largest peanut products is the partially defatted peanut, from which about 50 percent of the oil has been removed. These partially defatted peanuts have been marketed to some extent, and are being used in other food products, such as candy with a reduced calorie content, and as a replacement for black walnuts in confectionery products.

Future of oilseed proteins in foods. Although animal feeds promise to be an increasing major outlet for oilseed meals in both the domestic and export markets for several years, and problems remain for research on protein quality improvement, the exciting area for development is foods. Recent concern over nutrition, particularly in developing countries, but also in the United States, has brought protein foods and new sources of proteins to the public's attention.

Although scarcity of protein from conventional food sources will be an important factor in encouraging the use of oilseed proteins in the developing countries, this will not be the major factor in the United States, where protein supplies are plentiful, and average per capita consumption is relatively high. Rather, the potential economies to be realized from vegetable-protein products, and their advantage in formulated foods, will be a major incentive to development. Much information needs to be developed through research before the full potential in foods is realized.

Mycotoxins. Aflatoxin was first identified in connection with peanut meal fed to turkeys in Great Britain. Since then, we have carried on a broad program of research on the mycotoxins, particularly aflatoxin. Procedures have been developed for the detection and quantitative determination of aflatoxin in peanuts, cottonseed, and mixed feeds. Researchers at the Southern Division have prepared standards containing known amounts of aflatoxin B_1, B_2, G_1, and G_2. These standards are extremely useful in aflatoxin research, and have been supplied to investigators all over the world to help in their aflatoxin studies.

Practical methods are needed for rapid detection of aflatoxin contamination in truckloads of cottonseed and other oilseeds as they are delivered at the plant. We are now working on this problem, and one method tried out at a commercial plant is very promising.

We have also been working on procedures for inactivation of aflatoxin. Plant trials of the ammoniation procedure for inactivation of aflatoxin in cottonseed products were conducted during the past season with encouraging results. Feeding tests with some of these meals are now in progress.

Recognizing the potential threat posed by the discovery of aflatoxin in peanut meal in Britain, the U.S. peanut industry immediately took steps to avert such a threat if it should arise. To this end, the industry has worked in close cooperation with Utilization Research and the Consumer and Marketing Services, USDA, and with the Food and Drug Administration. The program thus established has assured the consumer a wholesome product and prevented losses to the industry.

Market quality research. My remarks have focused up to now on the processing of oilseeds and the products we can obtain from them. But

our interest extends back to the raw material itself — to the oilseeds as they arrive at the oil mill. We have a responsibility for serving the regulatory agencies which carry out the sampling, inspection, and grading of oilseeds. It is our job to provide them with scientific and statistical information and with equipment and instruments to do a better job. This work is centered mainly in our Market Quality Research Division.

This research backup is provided in various ways, starting with the sampling operation. With soybeans, we have made evaluations of commercial, diverter-type samples. USDA's Consumer and Marketing Service, which regulates sampling of grain and some oilseeds, bases their approval of a sampling system on the results of our work. With cottonseed, we worked jointly with the Cotton Division of Consumer and Marketing Service in devising the actual sampling equipment as well as its evaluation. With peanuts, we designed, built, and evaluated the probe sampler for in-shell peanuts and the automatic, diverter-type sampler for shelled peanuts.

Proceeding to the evaluation of the sample itself, we devise better and faster ways to measure quality factors, condition, damage, and defects. In some instances, as with peanuts, we have developed a whole series of devices and machines that, in effect, wholly revise the grading system. We now include in this system for peanuts a visual inspection procedure for eliminating peanuts contaminated with Aspergillus flavus, the mold that produces aflatoxin, from moving into food channels.

With cottonseed and soybeans, we have been studying the methods for quick measurement of oil and protein content. Inexpensive, rugged, and accurate instruments for these measurements could make it feasible to include these oilseed components in the grading, and hence in the pricing system, of these oilseeds. An instrument that might be capable of measuring these factors, and moisture content as well, is our newly devised, electronic light-transmittance meter, which is being readied for field testing.

There are many unsolved problems in this area of quality and defects evaluation, and it requires research of a very high calibre to adapt physical and chemical-measuring principles to the needs of the marketing situation. Not only are there unresolved problems in evaluation of maturity, insect, microbial, and physical damage in the raw oilseeds, but also methodology for analysis of the end products, (meals for example) is not entirely satisfactory for marketing and formulation. We will have no method for lysine determination, for example, that is fast and accurate enough to be really useful to the feed formulator or feed control agency. We intend to keep our effort in this area of marketing research as strong as possible and to try to avert what has happened many times in the past — a modern processing facility being hamstrung by an archaic system for evaluating its raw materials and end products.

NEW DIRECTIONS AND PLANS FOR COTTON INCORPORATED

by

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Cotton Incorporated
New York, N.Y.

Our organization is so new that even our name is new, for on January 1st, Cotton Producers Institute (CPI) became Cotton Incorporated (CI). Speaking of new, I am reminded of the old Kentucky moonshiner. When asked the difference between old and new, he remarked "the old was made yesterday and the new today."

CI, however, did not just come into being on January 1st, but as most of you know, it was created as a result of a Booz, Allen & Hamilton (BA&H) basic industry study that recommended that an independent organization be created to represent growers exclusively.

As a result, CPI (now CI) was spun off from the National Cotton Council (NCC). The Directors of CPI selected your speaker to carry out the task of creating this new organization.

Today, we are moving on all fronts from the farm and raw cotton handling, through spinning, weaving, and knitting to the consumer, today's king. Our name change was in recognition of our dedication to the cotton producers — they are the stockholders of Cotton Incorporated. CI is dedicated to selling more cotton, thereby increasing the demand for cotton and resulting in a higher price and more money in the pockets of the producer.

The major new direction is to the mills themselves. No longer relying exclusively on advertising, a sales department has been created to increase the mills' use of cotton fibers. Because if they don't spin, weave, or knit cotton, the consumer will not be able to find cotton products on the shelf.

The sales department has been created to

serve the mills' end products — men's and boy's, women's, children's and infant's wear, home furnishings, and industrials (including non-wovens). The basic creed under which they work is: If you want a mill to use more cotton, show how more profits can be made with your fibers. Thus emphasis is placed on a completely creative approach showing ideas that can be sold to the customers, not on how much advertising you are going to give a mill. Remember, consumers don't go out looking for fibers. They look for items that look good on them or in their homes.

CI's sales forces will interest mills in new constructions (weaves and knits). A recent example of this is a new 24-cut, cotton double knit. Another example, through American Laundry Machinery Industries' (ALMI) new vapor-phase, permanent press called Ameriset, is an opportunity to reverse the amount of polyester currently used in men's shirts. As you know, 70 percent of all shirts are 65-percent polyester and 35-percent cotton. Through this new process, we hope to give men a far more comfortable shirt, a 65 percent cotton with 35-percent polyester with a permanent press far superior to anything currently on the market.

Under former policies of 100-percent cotton or nothing, there was no way for cotton to fight back against blends. Now, for the first time, we are looking at blends through the eyes of cotton with its consumers in mind, by designing fabrics with comfort, durability, easy care, and of course, style, since today's housewives are the most fashion-minded consumers in history. Thus, our new policy of endorsing blends enables us to present cotton's inherent advantages to the mills so that cotton can be combined with the best synthetics. We are not turning our backs and running away from a fight. We recognize synthetics, their values and disadvantages. Consumer attitude studies will also play an important part in this battle. Of course, some co-op advertising will be used in the major markets of the country, giving cotton an end product, telling consumers where they can find it, and multiplying our dollars.

A marketing services division, consisting of fashion, product development, advertising, publicity, and market research, has been created to assist the sales division.

The fashion department is not just sitting back, letting styles develop and then follow, but is working on a 5-year program to influence fabric selection and colors favorable to cotton, just as the promoters developed a high-sheen look that was favorable to polyester, and pushed knits because of their greater running speed. This department will provide the sales staff with original designs and concepts so that they can work with mills and manufacturers through fabric libraries in New York, N.Y., Dallas, Tex., and Los Angeles, Calif. Not only will a collection of fabrics be offered, but a definite point of view in colors and constructions will be presented.

Product development in the marketing services division works with the sales force to solve short-range technical problems and strives to develop new constructions, particularly in knitting. This department developed Cotton-365. They recognized that woolen mills had a short season and convinced the operators that they could weave cotton. The result is a new fabric that looks just like wool! Since it can be worn in all seasons, we call it Cotton-365.

Advertising and publicity are coordinated to complement each other. The biggest change is in publicity, which will be used on a regularly scheduled basis with newspapers, TV, and radio in major markets.

The new policy direction for the research division places greater emphasis on produce development and a new staff of technical people to call on the mills' manufacturing facilities. Permanent-press and fire-retardant finishes are prime examples of product development work. Greater reliance and, hopefully, greater cooperation will be established with the USDA, land-grant colleges, and experimental stations for agricultural research of all types. CPI encouraged the development of narrow-row cotton which, in the areas where it has had sufficient tests, provides a 10-percent gain in yield.

Another new direction in research has been the adoption of a policy of joint ventures with industry — where each party has an opportunity to benefit financially from the success. This enables CI to have a partner who is driven by the profit motive, and it gives CI an opportunity to secure a return on its investment. An example of this is our sharing of royalties with ALMI in the Ameriset process mentioned earlier.

In summary, CI's new direction is not along the lines of a trade association, but a hard-hitting marketer of cotton geared to solving the problem in the marketplace of the seventies.

Now, if you believe in creative selling — and you know that I do or I wouldn't have accepted this challenge — you can see that CI will be using all of the modern tools of research and marketing to sell more cotton.

In closing, it seems only fitting to make this prediction — cotton sales will be upward in '71 and go on to a healthy increase throughout the seventies.

THE COTTONSEED INDUSTRY LOOKS AT ITS RESEARCH NEEDS

by
Richard A. Phelps
Anderson Clayton
Houston, Tex.

INTRODUCTION

While the author takes full responsibility for the statements made in this paper, his views have been influenced by the fine thoughts expressed by the National Cottonseed Products Association (NCPA) staff and the following members of the NCPA Research and Education Committee and associated Task Forces:

George C. Cavanagh	Ranchers Cotton Oil
Gene B. Cochran	Buckeye Cellulose Corp.
M. E. Ensminger	Consultants-Agriservices
A. A. Heidebrecht	ACCO Feeds
John Herzer	Cen-Tex Cotton Oil Mill
Robert J. Hlavacek	Hunt-Wesson Foods, Inc.
John C. Hunter	Proctor & Gamble Co.
T. J. Potts	Ralston Purina
Russell Reed	B & B Mills, Inc.
Leonard Smith	Cotton Incorporated
Carl E. Tetter	Western Cotton Products Co.
John H. Turner	USDA Cotton Research Station
Harold L. Wilcke	Ralston Purina
H. J. Witz	Producers Cotton Oil Co.
Ralph Woodruff	Delta Products Co.

HIGH-POPULATION COTTON

Since the future of the cottonseed industry is largely influenced by the future of the cotton crop, it seems appropriate to take a brief look at a major change in cotton production.

High-population cotton, known in some areas as close-grown or narrow-row cotton, has received a vast amount of publicity. The major objective of this production system is, of course, to reduce the cost of producing a pound of cotton by decreasing irrigation, pesticide, harvesting, and other costs. Numerous high-population trial plantings have been made across the Cotton Belt with varying degrees of success. New types of pickers and strippers designed for high-population cotton are being perfected and marketed. New, early maturing varieties of cotton are in various stages of development, and some present-day varieties may be satisfactory.

While optimum plant population, planting patterns, pesticide and irrigation schedules, etc. remain to be worked out, there are many reasons to be optimistic about the future of high-population cotton culture. One reason is that all bolls in the field should mature within a few days of each other, thus greatly reducing the period of pesticide application, etc. Cotton specialists in one State, Arizona, predict 1971 acreage of high-population cotton will be at least five times greater than 1970 acreage, or 25,000+ versus 5,000 acres.

COTTON BREEDING

In addition to the need for special types of cotton for high-population production systems, the cottonseed industry has a few needs centered around glandless cotton. One task force member suggested a survey to determine how we can make planting of glandless cottonseed progress at a faster pace. Our impatience should be tempered by the fact that the development of glandless cotton necessitated a major genetic change.

Secondly, we need to keep in mind that the seed traditionally represents only 10 to 15 percent of the value of the cotton crop, although with glandless cotton we recognize that the seed could represent a much higher percentage of the value of the total crop. Nevertheless, we should ask ourselves if we need an updated and precise evaluation of the economic value of glandless cotton.

Other glandless cotton needs include a complete evaluation of which lines of glandless show increased and which show decreased resistance to insects, and to which ones.

Another Research and Education Committee member has requested that cotton breeders place more emphasis on seed quality. Since he is in the audience, I hope that he will clarify his definition of quality, so the breeders can be guided accordingly. Another task force member has asked if genetically bald seed would be preferable to fuzzy seed from a milling standpoint.

COTTONSEED PROCESSING

One of the industry task forces has been wrestling for a couple of years with the task of trying to determine exactly why different lots of cottonseed respond so differently to mill processing. In other words, which components of cottonseed exert the most influence on processing results.

A related processing need is determination of whether the enzyme arginase, hydrogen bonding, or something else is responsible for the poor performance of underheated, glanded and glandless cottonseed meals. What are the minimum heating conditions necessary to insure optimum performance of cottonseed meal in nonruminant and ruminant rations?

How can we produce consistently low gossypol cottonseed meals by existing methods and by new processing methods? Can we justify the production of high protein (approximately 50 percent) cottonseed meals? Where do we sell the resulting hulls? Additional market research needs can be cited.

Additional processing needs of the industry that have been suggested include more studies of plant sanitation, including control of undesirable bacteria, air and water pollution control, improved hulling and separation, improved delinting with emphasis on cleaner linters and more economical delinting, a study of integrated crude seed to finished food operations, and rapid and economical protein analysis that can be used at the mill level.

AFLATOXIN

The aflatoxin problem is related to many research needs of the industry from new cotton varieties to new processing methods, and thus warrants a separate section in this paper.

A vast amount of time, money, and effort has been expended on aflatoxin research, and the reports would fill a large room. The studies have shown that aflatoxins are a field problem of cottonseed in some geographic areas and little or no problem in other areas. While much of the aflatoxin can be left in the field by leaving rotten and tight bolls on the stalk and by regular and proper cleaning around spindles of cotton pickers, some does enter the oil mills via field-contaminated seed. While some of these seed can be spotted by observing ultraviolet light fluorescence of the seed, other aflatoxin-contaminated seed do not seem to fluoresce, at least under commonly used short- and long-wave, ultraviolet lamps.

We have reason to suspect that insects play a significant role in the contamination of cottonseed in the field with fungi that produce aflatoxins. We also have reason to suspect that cotton bolls opening in a high-humidity, high-temperature environment are prime candidates for aflatoxin contamination.

Why don't we know, and what does the industry need to know?

1. What is the visible appearance of aflatoxin-contaminated cottonseed, especially nonfluorescent seed? Do they all look about the same, or is there a great range of colors, shapes, weights, etc?

2. What are the major environmental factors that influence field production of aflatoxins? Insects? Which insects? Which soil types? Is soil moisture a factor? Is altitude a factor? Do other nearby crops have an influence?

3. Do we need to plant varieties that are less stormproof (bolls fluff out better) and on nontraditional planting dates? Will okra leaf and frego bract cottons be free of aflatoxins?

4. How do we spot aflatoxin-contaminated cotton plants? Are the leaves more yellow? Plants shorter? More eaten up by insects?

5. Will high-population, short cotton increase or decrease field contamination of aflatoxins? Will skip-row planting reduce aflatoxins? Is bottom defoliation helpful and practical? Can we control aflatoxins in the field?

6. Can we economically sort out aflatoxin-contaminated seed anywhere along the processing chain?

7. What criteria do we use for sorting?

8. How do we draw a representative sample of seed for aflatoxin analysis and stay within practical limits?

9. How do we measure aflatoxins in incoming seed with the accuracy needed and within the very few minutes available between loads?

10. Which of other analytical errors are due to sampling and which to official analysis?

11. Will we be able to develop a practical, economical, and Food and Drug Administration (FDA)-approved process for removing or inactivating aflatoxins in cottonseed meal?

12. How do we convince the appropriate officials that cottonseed meals fed to domestic livestock and poultry in practical-type rations result in the production of safe and wholesome milk, meat and eggs?

PRODUCTS RESEARCH

Cottonseed meal. Among the many research needs of cottonseed meal are:

1. Determination of optimum and maximum level of cottonseed meals of various types in rations of broilers, layers, turkeys, replacement pullets, catfish, horses, and growing, gestating, and lactating swine. This should help to eliminate some of the problems associated with least-cost computer programs in use today.

2. Determination of the relative performance in range beef and some feedlot rations of cottonseed meal versus competing protein and nonprotein nitrogen products. Computer printouts are of little value unless accurate and meaningful data are fed to the computer.

3. Measurement of optimum, maximum, and necessary levels of amino acid fortification of cottonseed meal in nonruminant reactions, plus determination of the most economical source of these amino acids. Some data are

available; more are needed.

Cottonseed hulls. Among the many research needs of cottonseed hulls are:

1. Determination of the optimum level of cottonseed hulls necessary to maintain satisfactory butterfat levels in milk of cows fed high-energy rations.

2. Development of new outlets for cottonseed hulls to justify production of higher protein cottonseed meals.

3. Determination of the optimum utilization of cottonseed hulls in feedlot rations, both from the standpoint of level and type of ration.

Cottonseed oil. Cottonseed oil research suggestions included reduction of saturated fatty acids through breeding and cultural practices. Environment is known to alter the fatty acid composition of vegetable oils.

Another research suggestion was determination of why cottonseed oils of iodine value between 104 and 106 are difficult to winterize. Occasional dark colors of crude cottonseed oil were also mentioned; glandless cotton should minimize this problem.

NEW PRODUCTS

Food. The possibility and even probability of new cottonseed products being introduced in the near future is suggested by the U.S. Department of Agriculture (USDA) and private research reports.

Research, and especially market research, will be required to successfully launch these products, but the current and overriding need is volume production of glandless cottonseed.

In the area of food product research, the industry needs more information on the economics of cottonseed protein concentrates and isolates made from either glanded or glandless cottonseed. This would include a study of the several different types of processes involved.

A study of all potential and probable outlets for cottonseed flours, concentrates, and isolates would also benefit the industry. It is doubtful that all potential users of cottonseed protein are aware of its unique properties, such as solubility in an acid medium, that can be used to compliment existing protein products.

Feed. Several new types of feed products have been introduced in the past few years. The cottonseed industry needs to know if they can profit from similar products, such as: (1) Ammoniated or otherwise chemically modified cottonseed meal, and (2) cubed, complete hull and meal-containing rations for cattle and sheep.

OTHER OILSEEDS

Unfortunately, there is excess crushing capacity in most areas of the Cotton Belt. Consequently, expansion of present oilseed crops and development of potentially new sources of crushing material would be welcomed by the industry. The NCPA has performed admirably in promoting new oilseeds, especially sunflowers. The recent NCPA, USDA, and Cotton Incorporated-sponsored Sunflower Workshop at the Richard B. Russell Agricultural Research Center brought together growers, crushers, researchers, and others. The latest information on varieties, cultural practices, etc. was exchanged. Research needs were outlined. The workshop was a great success. Now we must get on with such tasks as developing sunflower hybrids, solving the carrot beetle problem, and putting money in the pockets of both sunflower growers and crushers.

Other oilseeds, such as sesame and high-oleic safflower, are being developed for some areas of the Cotton Belt. We need to stay informed on these developments and assist, wherever possible.

EDUCATION

In the context used here, "education" encompasses all subjects not conveniently placed in one of the above sections, but refers mainly to publicity, promotion, guidance, and in general, dissemination of information.

The industry needs to more effectively disseminate research data already developed from past research projects. Emphasis should be on short, basic, uncomplicated publications, better use of trade publications, and oil mill personnel.

A continued educational program is needed to help insure safe use of herbicides, insecticides, and other classes of pesticides.

More cooperation and coordination with Cotton Incorporated (formerly Cotton Producers Institute) and similar ogranizations should be mutually beneficial to the research needs of these organizations.

More awareness of the needs, limitations, and opportunities of livestock producers should aid the cottonseed industry in assessing their research needs as well as their opportunities. Full realization of the influence of linear programming is a must. Has our research and promotion encouraged full utilization of cottonseed meal, such as selection of selenium-rich cottonseed meal for rations manufactured in selenium-deficient areas?

One task force member listed the industry's primary need as "research on the business aspects of the industry." It is certainly worth a thought, but this is a subject that is more fittingly discussed by others.

FINIS

The list of research needs and subjects is obviously endless. The problem for all of us is not to find something to study. It is, first of all, to establish priorities and secondly, to find the necessary funds.

My colleagues and I hope that we have (a) caused you to contribute to the list of research needs, (b) encouraged you to help us find solutions to problems listed, and more importantly, (c) helped you see the road to increased profit in the oilseed-crushing industry.

THE POTENTIAL FOR OILSEEDS

by
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INTRODUCTION

This is a most appropriate time to examine the outlook for oilseeds for the near term and to attempt to analyze some of the contributing factors. Today, for example, vegetable oil prices are unusually high, and the apparent surplus and low prices of 1967-69 have virtually disappeared.

Before attempting to look to the future, a brief historical review of available figures on the worldwide production of fats and oils is in order. The following statistics are taken from the USDA's "World Agricultural Production and Trade" publication. In the following tables, actual world production figures for 1950 and 1960 are compared with the estimated 1970 production.

Table 1. World fats and oils production

Year	Short tons
1950	24,857,000
1960	31,630,000
1970 (est.)	42,520,000

World production of fats and oils has increased sharply in the last two decades. Total fats and oils production as shown in Table 1 was 24,857,000 short tons in 1950; 31,630,000 short tons in 1960 (an increase of 26 percent), and an estimated 42,520,000 short tons in 1970 (an increase of 34 percent).

Tables 2 through 6 supply greater detail in the major categories of marine oils, animal fats, industrial oils, palm oils, and the more important edible vegetable oils.

Table 2 shows a 65-percent increase for marine oils from 1950 to 1970, but note that the downtrend in whale oil is more than offset by the gain in fish oils, primarily menhaden and anchovy. Even so, the marine oils make up less than 4 percent of the total fats and oils production.

Table 2. World production of marine oils

Source	1950	1960	1970 (est.)
	Short tons	Short tons	Short tons
Whale	425,000	418,000	95,000
Sperm	55,000	122,000	165,000
Fish	375,000	511,000	1,150,000
Total	855,000	1,051,000	1,410,000

Table 3. World production of animal fats

Fats	1950	1960	1970 (est.)
	Short tons	Short tons	Short tons
Butter	3,520,000	4,250,000	5,000,000
Lard	3,680,000	4,000,000	4,310,000
Tallow and grease	2,350,000	3,440,000	4,700,000
Total	9,550,000	11,690,000	14,010,000

The 47-percent increase in animal fat production is mainly divided between butter and tallow-grease.

Table 4. World production of industrial oils

Type	1950	1960	1970 (est.)
	Short tons	Short tons	Short tons
Linseed	1,210,000	1,075,000	1,090,000
Castor	230,000	295,000	410,000
Oiticia	14,000	22,000	22,000
Tung	115,000	136,000	128,000
Total	1,569,000	1,528,000	1,650,000

Table 4 shows industrial oils relatively unchanged in total over the 20-year period. These

oils also account for less than 4 percent of the total worldwide fats and oils produced.

Table 5. World production in palm oils

Type	1950	1960	1970 (est.)
	Short tons	Short tons	Short tons
Coconut	1,975,000	2,240,000	2,340,000
Palm kernel	455,000	440,000	475,000
Palm	1,240,000	1,455,000	1,825,000
Babassu kernel	41,000	66,000	60,000
Total	3,711,000	4,201,000	4,700,000

The palm and coconut oils production increased 27 percent, 3.7 to 4.7 million short tons, from 1950 to 1970. Of even greater significance, perhaps, is the future of these oils. Plantings, particularly of oil palms, have increased as some of the developing nations recognize the need for an exportable cash crop.

Table 6. World production in edible vegetable oils

Type	1950	1960	1970 (est.)
	Short tons	Short tons	Short tons
Cottonseed	1,565,000	2,280,000	2,715,000
Peanut	1,835,000	2,325,000	3,390,000
Soybean	1,640,000	3,815,000	6,450,000
Sunflower seed	915,000	1,575,000	4,000,000
Rapeseed	990,000	1,280,000	2,265,000
Sesameseed	690,000	585,000	630,000
Olive Oil	1,267,000	1,300,000	1,300,000
Total	8,902,000	13,160,000	20,750,000

Among the edible vegetable oils, the most significant feature is the startling expansion in production of sunflower and soybean oils during the last two decades.

Table 6 gives the 20-year changes for the major edible oils.

Table 7. World production

Item	Increase 1969 to 1970
	Percent
Edible vegetable oils	7
Palm oils	3
Industrial oils	3
Animal fats	
Fish oils	2

Table 7 indicates the estimated increase (1969 to 70) in the production of the major fats and oils categories. Not only are the edible vegetable oils the largest in total volume, but they represent also that segment that is experiencing the greatest annual growth. It is expected that the larger increases into 1971 will be in soybean oil, sunflower oil, and rapeseed oil. The overall expected increase in production of about 5.5 to 6 percent will result in 1971 production of about 45 million short tons of all fats and oils.

Table 8. Fats and oils — potential production — pounds per capita

Year	Pounds per capita	World population
		Billion
1964	24.2	3.222
1966	24.9	3.355
1968	25.4	3.483
1970	25.8	3.610

Consumption per capita in United States — 50 to 52 lb. per year.

A significant contrast is illustrated in table 8. The potential world production per capita in 1970 is about 25.8 pounds of visible fats and oils, only slightly above the 1968 figure of 25.4 pounds. These per capita production figures are in stark contrast to consumption in the United States and several other developed countries. The trends to higher fat diets of convenience foods, fried chicken, french-fried potatoes, fish'n chips, and snacks high in oils are accounting for a significant part of this consumption of about 50 pounds of visible fats and oils per person per year. In the next few moments I will now deal more directly with several of the more dynamic oilseeds and their trends.

Soybeans. In the 10 years ending in 1966, United States' domestic usage of soybeans doubled and export soybeans quadrupled. Last year, the United States grew over 1.1 billion bushels of soybeans — which, incidentally, is about three-fourths of the world production. About two-thirds of these beans were crushed and the remaining one-third exported. That export, incidentally, represents about 90 percent of the world trade in soybeans. Combining the domestic crush and exports, the United States this year will experience a greater disappearance of beans than were produced — by about 169 million bushels expected for 1970-71.

To bring this a bit closer in geography, let us examine for a moment the soybean trend in the South and Southeastern United States. Over a period of 20 years, in this area, soybean acreage increased about eightfold, from 1.6 to 13.3 million acres, and production ninefold, from 33 to 304 million bushels. Yield per acre increased

by 12 percent during this period. Now soybean production in the South and Southeastern United States is about 25 percent of the total U.S. crop.

Average soybean yields per acre in the United States have increased from 23.1 bushels per acre in 1960 to 27.3 in 1970. Some experts predict average yields will reach 31 bushels per acre by 1975. Nevertheless, in order to meet the projected needs for soybeans in the United States in 1971, an increase in acreage is necessary. In both 1969-70 and 1970-71 soybean consumption significantly exceeeded production — by 84 and 169 million bushels, respectively, to result in an anticipated carryover as of September 1, 1971, of about 60 million bushels. This is significantly below the 200 million bushels thought desirable by students of the industry, including USDA. Demand for crush and for export has brought beans out of storage.

The projected need for soybean production in the United States in 1971 is about 1.4 billion bushels, in order to meet the need at home and abroad and to restore carryover reserves. Conflicting estimates have been made concerning the needed planting:

1. The American Soybean Association is calling for about a 10-percent increase over the 1970 acreage of 42.4 million acres.
2. Kenneth Frick, USDA's Chief of Agricultural Stabilization and Conservation Service (ASCS) operations, estimates a needed 8- to 9-million acre increase or nearly a 20-percent jump.
3. NSPA — the National Soy Processors Association — has called for a 10-million-acre boost, nearly 24 percent.

With large increases already history, and greater plantings a certainty, it is no wonder that processing capacity is going in around the world at a fast pace — at home, in Spain, France, the Netherlands, Bulgaria, Romania, and Japan, to mention a few. The crushing capacity in the United States jumped by about 50 percent in the last 5 years alone.

As research looks to the future, the challenge of a great deal of work is ahead. Dr. Phelps has already outlined many of the areas of research and development in which cottonseed is or should be involved. Universities, government laboratories, corporate labs, and growers' associations are supporting a similar search for soybean varieties giving higher plant density and yields per acre, better response to microorganism inoculation and micronutrient fertilizer application, greater resistance to plant disease and insect attack, etc. — all related of course, to the extreme variation in growing climates where soybean is a feasible crop. Canadian researchers are still seeking a variety that will prosper in the more northern areas.

An even greater technical effort is being expended in soy utilization in the food areas — high-protein drinks, synthetic milk, textured vegetable proteins, meat analogs, and calf-milk replacers from soy flours, concentrates, and isolates — not only for the developing countries, but for better nutrition at home.

Linseed oil. Flax, though not usually in the edible category, could possibly enter the picture. Flax is being processed into linseed oil and meal at less than 50 percent of the plant capacity in the United States. This downturn generally reflects loss of exterior paint markets to acrylic — latex paints, the switch to phenolic resins for brakeshoe lining and the rapid demise of the linoleum, oilcloths, and other product markets. Growers have responded with substantial acreage reductions in past years.

However, unbelievable low 8 to 9 cents per pound prices for linseed oil have prompted some current research at the USDA Peoria, Ill., Laboratory on the copper-chromite-catalyzed hydrogenation of the oil to obtain edible oils with very low linolenic acid content. Success could put linseed oil in the edible-oil category. Let me stress that this work is preliminary, but it illustrates well the attempts to take advantage of an economic situation in vegetable oils where traditionally, linseed oil has averaged 3 to 5 cents per pound higher than soybean oil, rather than the current 4 to 5 cents per pound below soybean oil.

Cottonseed. Agriculture in the South and Southeastern United States was built basically on cotton production and the businesses that served this industry. Acreage devoted to the production of cotton in this southern area reached a high in 1926. This past year, cotton acreage in the United States was estimated at about 12 million acres, with a USDA estimate for 1971 plantings of 11.8 million acres. Cotton and corn have yet another complication — the crop is not specifically grown for its oil and protein.

In the previous paper, Dr. Phelps outlined many of the efforts that need attention, ranging from high-population planting, shorter-season varieties, breeding and selection of varieties, processing technology, progress in aflatoxin controls, and product research in meals, hulls, and oil. I will leave the cotton situation to other speakers.

Peanuts. Another crop of special interest in this part of the country is peanuts. The bulk of the domestic peanut crop is used for peanut butter manufacture or as a nutmeat, and the peanut crop does not loom large as a major supplier of either oil or protein meal. With current high prices, the government has offered the equivalent of 500 tank cars of peanut oil for crush or export, during the past 2 to 3 weeks.

Rapeseed. While rapeseed is not a significant U. S. crop among oilseeds, it has shown the greatest worldwide growth within the last 2 years. Spurred by high oil prices, a 26-percent increase in 1970 over 1969 (equivalent to about 77 million bushels of soybeans) brings this product close in oil production to cottonseed on a worldwide basis. Although protein content of the meal is generally lower, quality is good, providing that thioglucoside content is minimal. Genetic manipulation to obtain seed low in thioglucoside content, as well as varieties low or zero in erucic acid content is underway and is promising.

Sunflower. In just 10 years sunflower oil production has doubled to reach the number 2 spot in edible oils, having passed cotton, peanut, and coconut oils.

In 1967, the Soviet Union doubled its export of sunflower oil to 728,000 tons. In the same year, Argentina, the second biggest sunflower seed producer, grew a record crop, and the Eastern European countries increased export shipments by nearly 60 percent over the previous year.

This 1967 deluge naturally gyrated the world markets. Soybean oil prices tumbled from 11 to 7 cents a pound; safflower seed prices dropped 15 to 20 percent; and sunflower oil itself fell from $250 to $150 a ton ex tank, Rotterdam.

In August, 1969, Russia decided to consume her oil domestically. Edible oil prices rose almost as quickly as they had earlier declined. With soybean oil reaching 11 to 13 cents a pound, crushing plants were pushing capacity to satisfy demand for vegetable oil around the world.

Total sunflower acreage in the United States is increasing:

	Southern U. S.	Red River Valley	Total
	Acres	Acres	Acres
1969	30,000	52,000	82,000
1970	15,000	75,000	90,000
1971 (est.)	below 5,000	200,000	205,000

If price structures in oil and protein hold about the same, sunflower will exceed one quarter of a million acres in 1972.

Ken Johnson, Cargill's sunflower project manager, predicts that by 1980 the United States will have a million acres planted in oil-bearing, hybrid sunflowers.

In looking to the future, this should be the decade of the hybrid sunflower. Russia, who has pioneered sunflower genetics, could have the hybrid planted commercially in 2 to 3 years, boosting yields perhaps by 20 percent or another million tons of seed. The hybrid will surely stimulate greater sunflower production in the United States.

A second factor in future production is the probability of higher oil content in seed. We expect to see still higher oil content in both the U.S. varieties and hybrids and the Russian sunflowers. These averaged about 50-percent oil on a dry basis in 1968 and about 49-percent in 1969. Plant scientists believe that they can achieve 55- to 60-percent oil content. This could represent another 10- to 20-percent increase in oil.

Breeding more disease resistance into sunflowers by wide genetic crosses also could be a significant factor that could bring another 10 to 20 percent in yield.

Thus, we may consider that if hybrids improve yields by 15 to 20 percent, if new disease resistance increases yields by 10 to 15 percent, and if new high-oil varieties are developed to contain 10 to 20 percent more oil per pound of seed, the cumulative increase in sunflower oil production, especially in the Soviet Union, could be dramatic — maybe 800,000 to 1,000,000 tons more oil on the same acreage — compared to a current, total worldwide edible oil production of 20 to 22 million short tons.

As for major breakthroughs in utilization, our research people doubt that there will be a discovery which will affect sunflower oil alone. Since most oils are interchangeable, a new use for one oil should affect others.

In contrast, it appears that soybeans will continue to be the leading source of vegetable oil, because of the strong demand for soybean protein meal to feed poultry and swine. Sunflowers, on the other hand, are raised principally for the high-premium oil and not for meal. So, the world's hunger for protein will continue to demand more soybean meal, resulting in more soybean oil.

Protein. Since we have already examined the oil situation, and since it will be further explored in the next paper, let us turn our attention to the protein aspects and some of the factors at work.

First, proteins come from many sources and are priced relatively. Since they vary in functionality (that is, usefulness in baking, moisture retention, emulsifying ability, and other properties), and also in nutritional excellence because of differences in amino acid composition and antigrowth factors, proteins are not always substitutable. The following chart illustrates some relative costs of certain proteins that suggest potential competition from various protein sources:

Estimated Costs of Selected Proteins

	Product	Price (cents/lb.)	Percent protein	Price/lb. protein (cents)
Oilseed	Peanut flour	7	59	12
	Cottonseed flour	5	50	10
	Soy flour	7-8	50	14-16
	Soy concentrate	18	70	26
	Soy isolate	35-39	90+	39-41
	Soy protein isolate (spun, textured and flavored)	50-80	variable	–
Milk products	Nonfat dry milk	21	36	58
	Casein (food grade)	28.0-32.5	85	33-38
	Sodium caseinate	42.5	90	47
Fish	Fishmeal	7	80	9
	FPC	42	80	52
Single-cell protein	Tarula (candidis)			
	yeast [food	15	50	30
	yeast [feed	4-6	50	8-12
	Petroleum derived protein-feed			
	yeast	8	50	16
	bacteria	8	70	11
	Petroleum derived protein-food			
	Yeast	17.5	50	35
	Bacteria	17.5	70	25
	Algae	200-550[1]	50	400-1100
	Yeast (active, dry)	40	37	108
Animal products	Steer beef (dressed)	40	13-19	210-307
	Chicken (diced, boneless, cooked)	90	20	450

[1] At rate of 100 pounds per day.

SOURCE: STANFORD RESEARCH INSTITUTE
Research Report by the Long-Range Planning Service
FABRICATED FOODS
May 1969

In addition to price competition, what are some of the trends already seen in proteins of the near future? This is, of course, a very complicated, dynamic picture related to many factors, including population, per capita trends (largely related to spendable income), food habits, poultry, swine, and livestock prices (and therefore numbers on feed), substitution of oilseed meals by other feed-protein sources such as single cell protein, genetic plant manipulation to increase protein content or improve protein quality, agronomic introduction of new protein crops, or extension of existing crops into new geographical areas, etc. Lack of sufficiently good input data, forecasting ability, or advance knowledge of technological advances prohibits accurately predicting the protein picture of 1980. Nevertheless, let's examine several trends already evident that will have a major influence on protein needs.

James W. Moore, President of the National Soybean Processors Association (FEEDSTUFFS: January 23, 1971) reported 1969 to 1970 domestic use of 13.5 million metric tons of soybean meal. This is projected to 14 million metric tons for 1970 to 1971. It is interesting to note that consumption of synthetic urea in ruminant diets in the United States is displacing

an estimated 1.5 to 2 million metric tons of protein meal. Brisk oilseed-meal demand can still be explained for 1969 to 1970 by expanded poultry and livestock numbers, favorable feeding ratios, and decreased fishmeal supplies, despite urea supplementation.

Livestock production has boomed. In 20 years, the number of hogs has increased by 55 percent; cattle production has increased 60 percent, and broiler production by 1,250 percent, from 149 million in 1950 to about 2 billion birds in 1970.

The present-day picture, however, is contradictory. Currently, we do see over-expansion in broilers, hogs, and turkeys. Cutbacks in replacement numbers have already begun.

Single-cell protein. The reference to protein prices also included single cell protein. A recent survey has indicated no less than 18 major companies (many of which are international) in various research, development, or pilot-plant efforts in the single-cell protein field. The fermentation industry in Japan alone forecasts use of 1.6 million metric tons of protein in animal feeds by 1978 — the protein to be grown by micro-organisms using petroleum as a feedstock. Full-scale plants will be operating in 1973. The 1.6 million metric ton figure is about the same as the soybean meal currently displaced by urea in United States feeds.

England, France, Nigeria, India, Taiwan and Russia have developments by the major petroleum companies underway. Yeast, bacteria, and algae can function on crude oil, natural gas, molasses, grain, sulfite liquor, and organic waste materials such as garbage and sewage. Major emphasis, however, has been on petroleum based, single-cell protein in laboratory and pilot-plant operations. Full-scale plant construction in Japan and Europe will be for petroleum-based products.

Urea and single-cell protein represent only two trends to protein production or replacement. Other factors and new technology will react dynamically with the proteins from oilseeds and even high-lysine corn and feed grains. The picture depends, as it always has, on the balance of oil and protein from all sources.

Future. Worldwide production of oilseeds is surging. Romania reported recordbreaking, 1969 sunflower seed production. Reports of reduced 1970 yields in Europe because of weather conditions were partially offset by the 18.5-percent increase in the sunflower harvest in Argentina; Brazil had its first one million ton soybean crop. Canada nearly doubled its rapeseed planting in 2 years, and a surge of palm oil can be expected from Malaysia, Columbia, Indonesia, the Ivory Coast, and Nigeria, as well as other African countries.

Domestically, we expect a 10-percent increase in soybean acreage (depending on whose estimate is quoted), increased sunflower acreage, slightly decreased cotton acreage, and no especially significant change in safflower production next year.

The United States has a capacity to grow much greater quantities of oilseeds, particularly soybeans, as acreage is pushed into Georgia, Missouri, the Carolinas, Kansas, and other States. Demand for this production will depend greatly on the production, consumption, competition, and population factors outside this country. As these other countries become more self-sufficient by their own production of oil, protein, and substitutes, their dependence on exports from the United States can be expected to diminish.

TRENDS IN U.S. CONSUMPTION OF EDIBLE OILS

by
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The discussion of edible-oil-consumption trends necessarily encompasses the entire food-fat complex because of the interchangeability and substitutability among the various commodities and products. Edible oils have comprised an increasingly larger share of a greatly expanded domestic market for fats and oils.

FOOD-FAT USE PER PERSON RISING

U.S. consumption of food fats and oils have increased over the past 20 years — from an annual average of around 44 pounds per person (fat-content basis) to about 53 pounds. The gain has occurred largely since the mid-1960's.

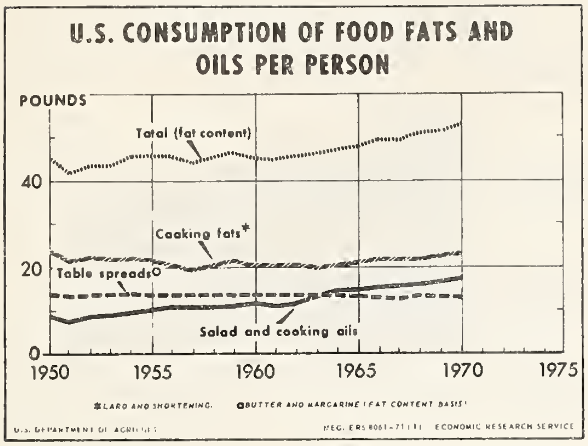

Chart 1

Increased use of salad and cooking oils, shortening, and margarine has more than offset declines in butter and lard. Over the years, there has been a distinct trend away from solid fats to liquid oils, and from animal fats to vegetable oils.

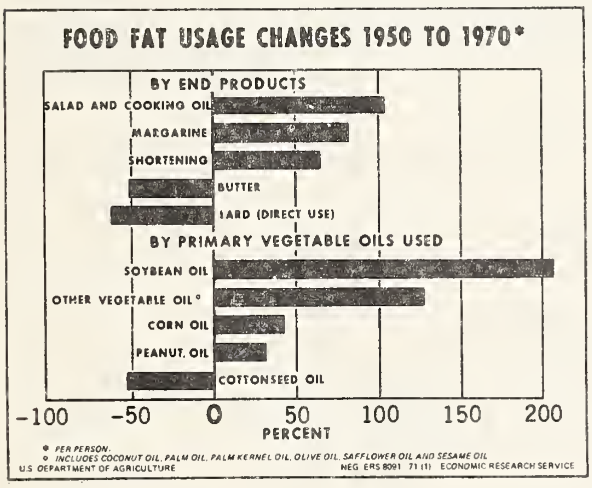

Chart 2

Substitution has taken place both among the three major food-fat product groups — table spreads (butter and margarine), cooking fats (lard and shortening), and salad and cooking oils — as well as among products within each group.

Generally speaking, increased use of food fats partly reflects the changing eating habits of Americans — in time, place, and frequency of eating. The use of "convenience" and "snack" foods has increased sharply. This is related to the rising proportion of young people in the population, along with more leisure time. A similar phenomenon has been the growth in the "fast food" enterprises, including hamburger and french fry franchises, the chicken and fish carryout, and a whole range of others. Thus, expanded use of "convenience foods", along with increased "away from home eating", probably are the predominant factors associated with increased use of food fats in recent years.

Soybean oil has emerged as the leading vegetable oil in the U.S. food-fat economy — accounting for over half of the total fats and oils going into food products. Sharply expanded use of soybean oil has more than offset the decline in cottonseed oil — once the major edible oil produced and consumed in this country.

Fats and oils economists usually analyze food-fat consumption patterns from two aspects — the contribution of each fat or oil to the total fat consumed as such in the United States, and also the amount of each that is consumed in the various food-fat products. I shall follow this technique in my presentation today. So let us first consider the trends for the primary fats and oils relative to aggregate consumption patterns.

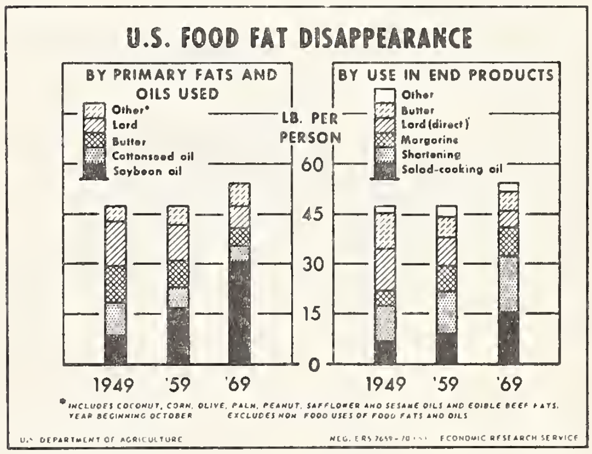

Chart 3

EDIBLE OIL USAGE TRENDS UP WHILE ANIMAL FATS DECLINE

Total U.S. domestic disappearance of primary fats and oils in food products rose from around 6 1/2 billion pounds in the early 1950's to about 11 billion pounds last year — an increase of some 60 percent. However, distribution patterns among the various types of fats and oils utilized changed significantly.

Table 1. **Food fats and oils: Per capita consumption, by type of product, 1950–70 1/**

Calendar year	Table spreads (product weight)			Cooking fats			Other edible fats and oils (mainly cooking and salad oils)						Total			
							Oil used in							Fat content		
	Butter	Margarine	Total	Lard (direct-use) 2/	Short-ening	Total	Mayonaise and salad dressing	Potato chips 3/	Frozen french fries 3/	Mellorine 3/	Other 4/	Total	Product weight 5/	Animal fats	Vegetable oils	Total
	— Pounds —															
1950	10.7	6.1	16.8	12.6	11.0	23.6	2.6	6/	6/	6/	6.0	8.6	49.1	21.9	24.0	45.9
1951	9.6	6.6	16.2	12.3	9.0	21.3	2.6	6/	6/	6/	5.1	7.7	45.2	22.2	19.9	42.1
1952	8.6	7.9	16.5	11.8	10.2	22.0	2.7	6/	6/	.03	6.0	8.7	47.3	21.3	22.8	44.1
1953	8.5	8.1	16.6	11.4	10.2	21.7	2.7	6/	6/	.06	6.3	9.1	47.2	20.9	23.2	44.1
1954	8.9	8.5	17.4	10.2	11.8	22.0	2.6	6/	6/	.07	6.8	9.5	48.8	19.7	25.8	45.5
1955	9.0	8.2	17.2	10.1	11.5	21.6	2.9	6/	6/	.07	7.5	10.5	49.2	20.9	25.0	45.9
1956	8.7	8.2	16.9	9.8	10.9	20.7	3.0	1.0	.08	.07	6.8	10.9	48.5	21.4	23.8	45.2
1957	8.3	8.6	16.9	9.4	10.4	19.8	3.2	1.2	.08	.07	6.2	10.8	47.6	20.2	24.2	44.4
1958	8.3	9.0	17.3	9.6	11.3	20.9	3.3	1.1	.14	.08	5.9	10.5	48.7	20.1	25.2	45.3
1959	7.9	9.2	17.1	8.8	12.6	21.4	3.5	1.3	.16	.09	6.0	11.1	49.6	20.0	26.2	46.2
1960	7.5	9.4	16.9	7.6	12.6	20.2	3.5	1.3	.24	.09	6.5	11.5	48.5	18.5	26.7	45.3
1961	7.4	9.4	16.8	7.7	12.8	20.5	3.5	1.4	.28	.10	5.9	11.2	48.4	19.4	25.7	45.1
1962	7.3	9.3	16.6	7.2	13.4	20.5	3.5	1.5	.28	.10	6.3	11.7	48.9	18.7	27.0	45.7
1963	6.9	9.6	16.5	6.4	13.5	19.9	3.9	1.6	.34	.10	7.2	13.1	49.5	18.2	28.1	46.3
1964	6.8	9.7	16.5	6.3	13.7	20.0	3.9	1.7	.34	.10	8.4	14.2	50.7	17.2	28.3	47.5
1965	6.4	9.9	16.3	6.4	14.0	20.4	4.1	1.8	.52	.10	7.7	14.1	50.7	17.2	30.5	47.7
1966	5.7	10.5	16.2	5.5	15.9	21.4	4.3	1.9	.54	.10	8.3	15.1	52.9	15.9	33.7	49.6
1967	5.5	10.5	16.0	5.4	15.9	21.3	4.4	1.9	.53	.10	8.1	15.1	52.3	16.2	33.0	49.2
1968	5.6	10.8	16.5	5.6	16.2	21.8	4.6	1.9	.55	.10	8.9	16.0	54.2	16.8	34.2	51.0
1969	5.4	10.8	16.2	5.1	17.0	22.1	4.8	2.0	.61	.10	9.2	16.7	55.0	14.9	36.9	51.8
1970 6/	5.1	11.0	16.1	4.8	17.9	22.7	5.0	2.1	.65	.10	9.6	17.4	56.2	15.0	38.3	53.3

1/ Civilian consumption only.
2/ Excludes use in margarine, shortening, and nonfood products.
3/ Estimated from data on production of item.
4/ Computed as a residual. Includes retail trade and use of oil in commercial frying, roasting, bakery and other products including confectionary fats, toppings, milk fillings, and other specialty fats.
5/ Table spreads and cooking fats plus oil content of other edible fats and oils.
6/ Preliminary — based on data through November.

Source: USDA; Economic Research Service: Fats and Oils

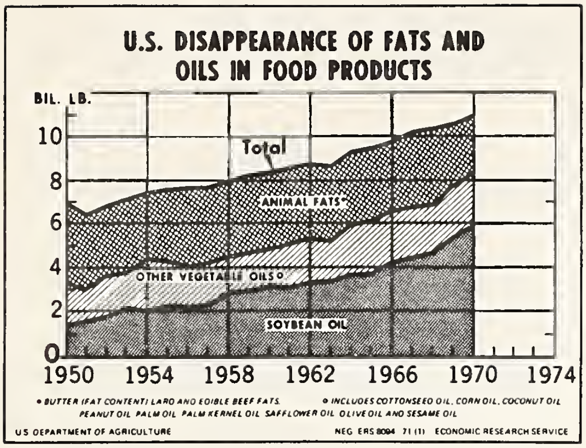

Chart 4

Twenty years ago, the food-fat market was split approximately equally between animal fats (lard, butter, and edible beef fats) and edible vegetable oils. In 1970, however, edible oils had increased to 75 percent of the total fats and oils disappearing into domestic food products, whereas the animal fat share dropped to 25 percent. On a per capita basis, edible-vegetable-oil consumption doubled during the two decades — from around 22 to 40 pounds. Animal fat usage, on the other hand, fell from 22 to 13 pounds per person.

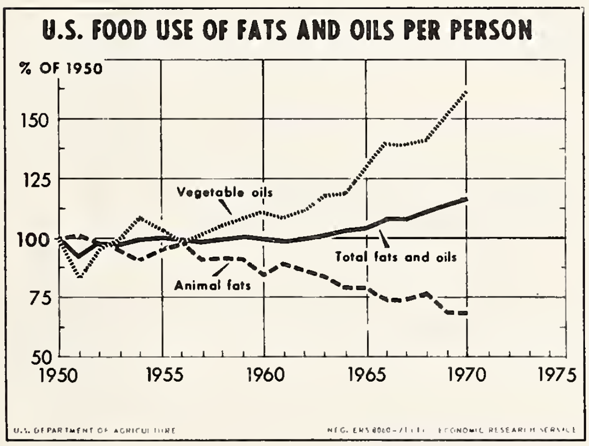

Chart 5

Edible vegetable oils moved into the dominant position in the U.S. food-fat economy mainly because of (1) the sharp growth in output of soybean oil at competitive price levels; (2) the increased hydrogenation processing which made possible the manufacture of shortenings entirely from vegetable oils; (3) the consumer shift from butter to lower-priced vegetable oil margarines; and (4) the trend of diet- and cholestrol-conscious consumers toward using more liquid (unsaturated) oils and less solid (saturated) fats. The edible oil industry has met the challenge for unsaturated fats by producing greater quantities of vegetable oil shortenings, salad and cooking oils, "soft" margarines, and by using more edible oils in commercial food preparations.

SOYBEAN OIL DOMINATES MARKET

Soybean oil used in food-fat products domestically has expanded from around 1.5 billion pounds in the early 1950's to 6.0 billion in 1970 — a 300-percent increase. Two decades ago, soybean oil and cottonseed oil each accounted for 20 percent of all food fats and oils used. Lard was in first place with 32 percent of the market. But since then, soybean oil usage moved up swiftly (while lard and cottonseed oil declined), and in 1970, soybean oil accounted for 55 percent of the total food-fat market.

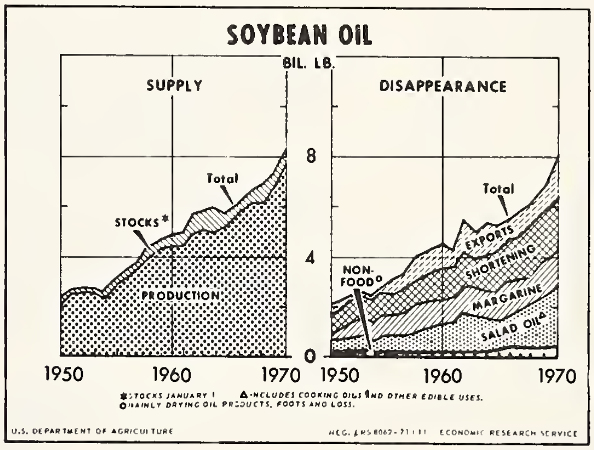

Chart 6

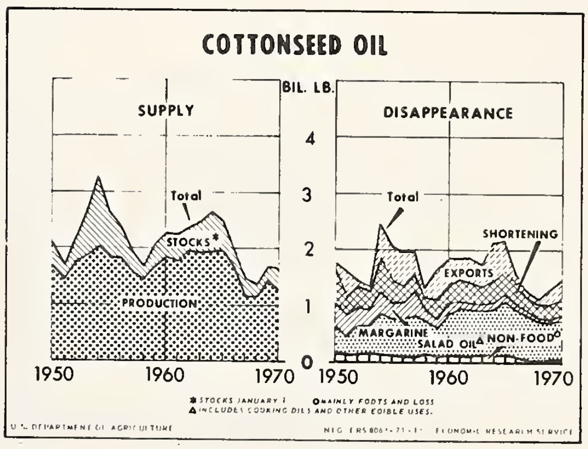

Chart 7

Table 2. U. S. domestic disappearance of fats and oils in food products, by type of fat or oil, total and per capita, 1950–70 1/

Calendar year	Vegetable oil											Animal fats				Fats and oils used in food products for domestic consumption		U.S. population 4/
	Soybean	Cotton-seed	Corn	Coconut	Peanut	Palm	Palm kernel	Safflower	Olive	Sesame	Total vegetable oils	Butter 2/	Lard	Beef fats	Total animal fats	Total 3/	Per capita	
									Total million pounds								Pounds	Million
1950	1,446	1,445	223	129	103	---	26	---	79	4	3,455	1,327	2,050	156	3,533	6,988	45.9	152.3
1951	1,536	1,043	211	142	114	---	11	---	40	5/	3,097	1,205	2,059	131	3,395	6,492	41.9	154.9
1952	1,911	1,218	201	191	84	1	11	---	46	5/	3,663	1,090	2,054	144	3,288	6,951	44.1	157.6
1953	2,128	1,148	235	183	47	1	20	---	45	5/	3,807	1,104	2,007	187	3,298	7,105	44.4	160.2
1954	2,002	1,725	232	204	57	16	32	---	61	5/	4,329	1,187	1,776	230	3,193	7,522	46.1	163.0
1955	2,309	1,341	233	194	48	---	36	---	52	1	4,214	1,237	1,986	239	3,462	7,676	46.3	165.9
1956	2,155	1,252	254	226	66	---	42	---	45	5/	4,040	1,231	2,113	276	3,620	7,660	45.4	168.9
1957	2,296	1,223	272	233	66	---	47	---	49	1	4,186	1,176	1,990	302	3,468	7,654	44.5	172.0
1958	2,824	1,028	269	253	62	---	47	---	53	1	4,537	1,182	1,974	308	3,464	8,001	45.7	174.9
1959	2,912	1,064	309	180	81	3	49	---	54	5/	4,652	1,145	2,065	315	3,525	8,177	46.0	177.8
1960	3,011	1,225	310	172	62	1	53	---	51	1	4,886	1,113	1,889	328	3,330	8,216	45.5	180.7
1961	3,041	1,276	326	206	94	30	59	---	59	1	5,092	1,112	1,998	424	3,534	8,626	46.9	183.8
1962	3,275	1,239	343	267	62	29	70	40	58	1	5,379	1,131	1,959	407	3,497	8,876	47.5	186.7
1963	3,258	1,169	351	224	69	17	69	52	33	1	5,243	1,083	1,871	510	3,464	8,707	46.0	189.4
1964	3,739	1,348	412	254	58	11	67	38	67	1	5,995	1,097	1,704	538	3,339	9,334	48.6	192.1
1965	3,750	1,410	427	272	70	13	80	51	44	1	6,118	1,040	1,772	529	3,334	9,459	48.6	194.6
1966	4,296	1,217	396	346	144	52	65	84	49	1	6,650	911	1,645	533	3,089	9.739	49.5	196.9
1967	4,365	1,076	403	361	173	62	108	158	56	2	6,764	1,097	1,757	545	3,399	10,163	51.0	199.1
1968	4,734	956	404	377	200	77	98	65	63	1	6,975	957	1,861	549	3,367	10,342	51.4	201.2
1969	5,474	917	387	401	153	129	93	123	58	2	7,737	910	1,574	519	3,003	10,740	52.9	203.2
1970 7/	6,000	925	425	375	195	90	73	100	65	2	8,250	875	1,350	530	2,755	11,000	53.5	205.6
									Per capita pounds								Percent distribution Vegetable oils	Animal fats
1950	9.5	9.5	1.5	0.8	0.7	---	0.2	---	0.5	6/	22.7	8.7	13.5	1.0	23.2	45.9	49	51
1951	9.9	6.7	1.4	9	.7	---	6/	---	.3	6/	20.0	7.8	13.3	.8	21.9	41.9	48	52
1952	12.1	7.7	1.3	1.2	.5	6/	.1	---	.3	6/	23.2	7.6	13.1	.8	20.9	44.1	53	47
1953	13.3	7.2	1.5	1.1	.3	6/	.1	---	.3	6/	23.8	6.9	12.5	1.2	20.6	44.4	54	46
1954	12.3	10.6	1.4	1.3	.3	0.1	.2	---	.4	6/	26.6	7.3	10.9	1.4	19.6	46.1	58	42
1955	13.9	8.1	1.4	1.2	.3	---	.2	---	.3	6/	25.4	7.5	12.0	1.4	20.9	46.3	55	45
1956	12.8	7.4	1.5	1.3	.4	---	.2	---	.3	6/	23.9	7.3	12.5	1.6	21.4	45.4	53	47
1957	13.3	7.1	1.6	1.4	.4	---	.3	---	.3	6/	24.3	6.8	11.6	1.8	20.2	44.5	55	45
1958	16.1	5.9	1.5	1.4	.4	---	.3	---	.3	6/	25.9	6.8	11.3	1.8	19.8	45.7	57	43
1959	16.4	6.0	1.7	1.0	.5	6/	.3	---	.3	6/	26.2	6.4	11.6	1.8	19.8	46.0	57	43
1960	16.7	6.8	1.7	1.0	.3	6/	.3	---	.3	6/	27.0	6.2	10.5	1.8	18.4	45.5	59	41
1961	16.5	6.9	1.8	1.1	.5	.2	.3	---	.3	6/	27.7	6.1	10.9	2.3	19.2	46.9	59	41
1962	17.5	6.6	1.8	1.4	.3	.2	.4	.2	.3	6/	28.8	6.1	10.5	2.2	18.7	47.5	61	39
1963	17.2	6.2	1.9	1.3	.3	.1	.4	.2	.2	6/	27.7	5.7	9.9	2.7	18.3	46.0	60	40
1964	19.5	7.0	2.1	1.3	.3	.1	.3	.2	.3	6/	31.2	5.7	8.9	2.8	17.4	48.6	64	36
1965	19.3	7.2	2.2	1.4	.4	.1	.4	.3	.2	6/	31.4	5.3	9.1	2.7	17.1	48.6	65	35
1966	21.8	6.2	2.0	1.8	.7	.3	.3	.4	.2	6/	33.8	4.6	8.4	2.7	15.7	49.5	68	32
1967	21.9	5.4	2.0	1.8	.9	.3	.5	.8	.3	6/	34.0	5.5	8.8	2.7	17.1	51.0	67	33
1968	23.5	4.8	2.0	1.9	1.0	.4	.5	.3	.3	6/	34.7	4.8	9.2	2.7	16.7	51.4	68	32
1969	26.9	4.5	1.9	2.0	.8	.6	.5	.6	.3	6/	38.1	4.5	7.7	2.6	14.8	52.9	72	28
1970 7/	29.2	4.5	2.1	1.8	.9	.4	.4	.5	.3	6/	40.1	4.3	6.6	2.6	13.4	53.5	75	25

1/ Includes disappearance into products for both civilian and military consumption. Data not adjusted for changes in finished product stocks and excludes exports.
2/ Fat content of butter which averages 80.5% of total weight.
3/ Includes butter on fat content basis.
4/ Total population (50 States) including armed forces overseas as of July 1 each year.
5/ Less than 500,000 pounds.
6/ Less than 0.1 pounds.
7/ Preliminary — based on data through November.
Source: USDA; Economic Research Services; Fats and Oils

Table 3. Fats and oils used in manufacture of food products, by product, and fat or oil, 1950–70

Calendar year	Margarine: Soybean oil	Cottonseed oil	Corn oil	Safflower oil	All other edible oil 1/	Total edible oils	Lard and beef fats	Vegetable stearine	Total fats and oils	Shortening: Soybean oil	Cottonseed oil	Palm oil	Coconut oil	All other oils 2/	Total edible oils	Lard and beef fats	Vegetable stearine and glycerides	Total fats and oils
	— Million pounds —																	
1950	312	418	1	---	20	751	9	4	764	841	549	---	---	40	1,430	208	89	1,727
1951	473	334	4	---	19	830	11	11	851	731	335	---	20	47	1,133	223	48	1,405
1952	652	354	3/	---	3	1,009	13	24	1,046	851	388	---	83	9	1,281	266	66	1,613
1953	726	275	1	---	14	1,016	21	12	1,049	903	376	---	2	6	1,288	273	117	1,681
1954	665	397	3/	---	10	1,072	17	17	1,106	918	640	---	15	26	1,599	231	138	1.969
1955	746	278	3/	---	13	1,037	22	16	1,075	930	439	---	4	24	1,397	452	139	1,988
1956	752	283	1	---	12	1,048	38	24	1,111	782	323	---	6	26	1,127	600	123	1,855
1957	874	237	3/	---	11	1,122	34	24	1,182	796	272	---	8	13	1,089	602	132	1,824
1958	1,070	145	1	---	10	1,226	24	19	1,269	1,055	239	---	12	10	1,316	570	125	2,011
1959	1,094	124	20	---	10	1,248	44	4/	1,291	1,143	320	---	20	11	1,494	750	4/	2,244
1960	1,105	136	55	---	9	1,305	62		1,367	1,169	365	---	10	9	1,553	748		2,302
1961	1,062	139	89	---	17	1,307	78		1,386	1,160	356	11	26	28	1,581	878		2,459
1962	1,058	106	99	6	46	1,315	80		1,394	1,362	367	16	27	15	1,787	909		2,696
1963	1,049	104	136	22	44	1,365	95		1,451	1,228	330	14	19	14	1,605	1,007		2,611
1964	1,139	101	150	12	21	1,423	77		1,500	1,388	378	11	18	21	1,816	876		2,693
1965	1,112	114	161	10	23	1,420	114		1,535	1,471	403	13	20	17	1,924	844		2,768
1966	1,294	106	157	46	19	1,622	87		1,710	1,734	370	38	38	30	2,210	982		3,192
1967	1,249	78	176	42	24	1,569	135		1,703	1,741	273	61	40	46	2,161	1,082		3,243
1968	1,240	70	179	42	21	1,552	168		1,720	1,842	248	72	41	35	2,238	1,088		3,326
1969	1,333	76	172	43	21	1,645	98		1,743	2,086	248	111	48	37	2,530	958		3,489
1970 5/	1,450	68	183	22	15	1,735	65		1,800	2,300	315	80	42	38	2,775	935		3,710

Calendar year	Salad and cooking oils 6/: Soybean oil	Cottonseed oil	Corn oil	Peanut oil	Safflower oil	Olive	All other edible oils	Total edible oils	Other edible products 7/: Soybean oil	Cottonseed oil	Corn oil	Coconut oil	Palm oil	Palm kernel oil	Peanut oil	Safflower oil	Other	Total other edible products
	— Million pounds —																	
1950									293	457	221	129	---	22	85	---	98	1,305
1951									351	373	206	121	---	1	76	---	72	1,200
1952									408	477	200	158	1	6	75	---	62	1,387
1953									497	497	236	174	---	15	42	---	51	1,512
1954									419	687	231	257	---	28	43	---	61	1,726
1955									633	624	229	186	---	28	41	---	59	1,800
1956									621	647	252	213	---	34	57	---	45	1,869
1957									626	714	267	220	---	42	57	---	53	1,979
1958	8/	8/	8/	8/	8/	8/	8/	8/	699	644	265	237	---	47	53	---	53	1,998
1959	850	650	272	40	---	54	4	1,870	23	14	12	157	3	49	36	---	111	405
1960	887	752	247	28	---	51	1	1,966	27	18	6	158	1	53	28	---	69	360
1961	1,019	818	210	76	---	59	3	2,185	22	10	1	176	4	48	12	---	29	302
1962	1,437	817	210	46	6	58	17	2,591	21	8	11	195	9	22	11	---	6	283
1963	1,317	764	202	55	27	33	1	2,399	16	10	10	201	2	26	8	---	78	351
1964	1,638	906	241	50	20	67	---	2,922	22	12	13	229	---	58	4	---	32	370
1965	1,564	915	239	53	9	44	---	2,824	35	24	11	234	13	67	10	---	4	398
1966	1,860	746	217	115	12	49	5	3,004	47	26	5	284	14	68	8	1	12	465
1967	1,912	625	231	133	42	54	3	3,000	52	25	3	298	1	78	8	10	8	483
1968	2,036	541	242	156	22	63	3	3,063	43	44	8	272	4	90	19	5	5	490
1969	2,243	513	248	124	21	58	2	3,209	35	47	8	271	18	70	10	4	11	474
1970 5/	2,450	550	250	133	15	65	2	3,465	40	55	5	285	15	65	9	5	11	490

1/ Mainly peanut and coconut oils. 2/ Mainly peanut, palm, and coconut oils. 3/ Less than 500,000 pounds. 4/ Not reported separately by Census beginning 1959. 5/ Preliminary — based on data through November. 6/ Fully processed liquid vegetable oils. Includes uses in mayonnaise and salad dressings, potato products, bakery products, and in fish canning, etc. Not reported separately prior to 1959; 1950-58 included in "other edible" products. Includes salad and cooking oils processed for export. 7/ Mainly salad and cooking oils prior to 1959. Beginning with 1959 includes all food fats and oils used other than butter, lard, margarine, shortening, and salad and cooking oils. 8/ Not reported separately prior to 1959. Data for 1950-58 included in "other edible" products.

Source: USDA; Economic Research Service; Fats and Oils

Soybean oil has gained an ever-increasing share of the food-fat market, mainly because production responds directly to expanding demand for soybean products. Output of cottonseed oil and lard is unresponsive to demand and price changes, since they are byproducts of the cotton and hog industries. Butter output is affected by the supply and use of milk in other dairy products.

The predominance of soybean oil is even more striking when edible vegetable oils are analyzed as a group. During 1950-70, soybean oil's share gained from about 42 percent of the edible oils to over 70 percent last year. With the declining market for cotton, cottonseed oil fell from 42 percent of total oils used in the early 1950's to 11 percent in 1970. The volume of corn, coconut, peanut, palm kernel, and safflower oils used trended upward over the past two decades, but the percentages remained relatively small.

In 1970, soybean oil accounted for 80 percent of the fats and oils going into the manufacture of margarine, 71 percent of those used in salad and cooking oils and 62 percent of the fats and oils used in shortenings.

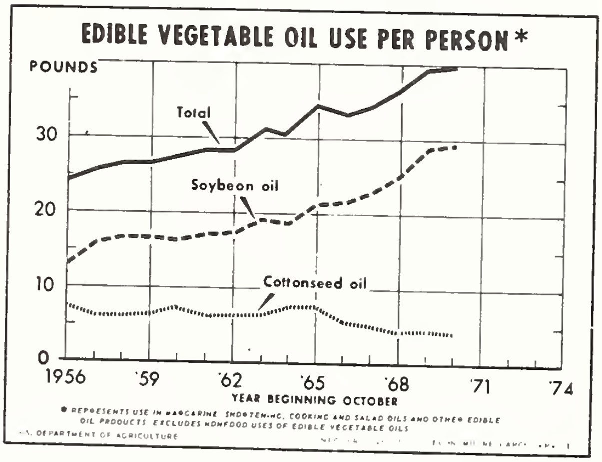

Chart 8

TRENDS IN CONSUMPTION OF FOOD FAT-PRODUCTS

Now we will briefly look at the changing consumption pattern of food-fat products.

A wide variety of products based on edible fats and oils is available on today's market. Butter, margarine, lard, shortening, salad and cooking oils, mayonnaise, and a host of salad dressings (french dressing, italian, and other specialities) are some of the products that are either based wholly on fats and oils or contain fat or oil as a principal ingredient. Many of these products are also sold in commercial quantities to bakeries, food processors, institutions, and restaurants.

During 1950-70, the most significant development has been the continuing trend toward the consumption of products prepared from vegetable oils and away from those prepared for animal fats. Butterfat consumed as butter, and the direct use of lard declined steadily during this period. Concurrent with these changes, salad and cooking oils increased sharply. Similarly, margarines and shortenings, which are produced principally from vegetable oils, increased in consumption.

The trend toward the more extensive use of edible vegetable oils, coupled with the practice of margarine and shortening manufacturers to produce more unsaturated products, has undoubtedly resulted in an increase in the ratio of unsaturated to saturated fatty acids in the U.S. diet.

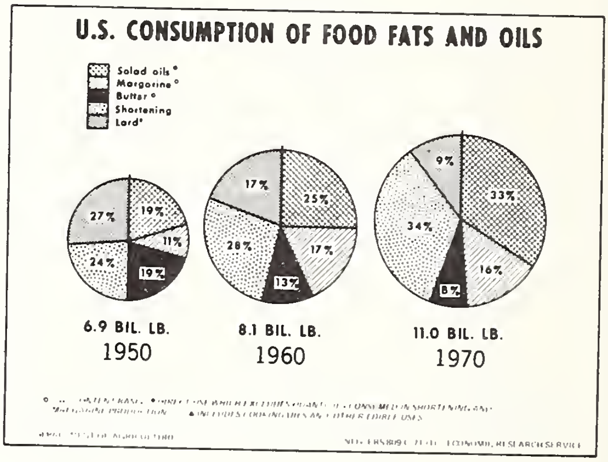

Chart 9

MAJOR SHIFT TO SALAD AND COOKING OILS

Salad and cooking oils have led the increase in U.S. consumption of food-fat products, the volume advancing from around 1.2 billion pounds per year in the early 1950's to 3.1 billion pounds in 1970. The growth pattern was fairly steady until the mid-1960's, when it started to rise precipitously. On a per capita basis, usage during 1950-70 rose from around 7 pounds to a record 15 pounds last year.

The sharp uptrend in salad- and cooking-oils consumption reflects increased use of liquid, edible oils themselves by the retail trade, along with the growing use of vegetable oils in commercial frying, roasting, and in the production of prepared foods such as mayonnaise, salad dressings, potato chips, frozen french fries,

Table 4. Salad and cooking oils: U. S. production, fats and oils used in manufacture, and domestic consumption, 1959–70 1/

Calendar year	Salad and cooking oils 2/			Total oils used in salad and cooking oil manufacture 2/	Edible vegetable oils consumed in salad and cooking oil manufacture (% of total)							Cooking and salad oil domestic consumption (civilian)	
	Domestic production	Imports 3/	Total		Soybean	Cottonseed	Corn	Peanut	Safflower	Olive	All other	Total	Per capita
	Mil lb.	Mil. lb.	Mil. lb.	Mil. lb.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Mil. lb.	Lb.
1959	1,808	54	1,862	1,870	45.5	34.8	14.5	2.1	- - -	2.9	.2	1,486	8.5
1960	1,915	51	1,966	1,966	45.1	38.2	12.6	1.4	- - -	2.6	.1	1,630	9.2
1961	2,124	59	2,183	2,185	46.6	37.5	9.6	3.5	- - -	2.7	.1	1,661	9.2
1962	2,532	58	2,590	2,591	55.5	31.5	8.1	1.8	0.2	2.2	.7	2,021	11.0
1963	2,359	33	2,392	2,399	54.9	31.8	8.4	2.3	1.1	1.4	.1	2,066	11.1
1964	2,846	67	2,913	2,922	56.1	31.0	8.2	1.7	.7	2.3	- - -	2,249	11.9
1965	2,773	44	2,817	2,824	55.4	32.4	8.5	1.9	.3	1.5	- - -	2,398	12.5
1966	2,947	49	2,996	3,004	61.9	24.8	7.2	3.8	.4	1.7	.2	2,463	12.9
1967	2,922	54	2,976	3,000	63.7	20.8	7.7	4.5	1.4	1.8	.1	2,474	12.6
1968	2,996	63	3,059	3,063	66.5	17.7	7.9	5.1	.7	2.0	.1	2,665	13.5
1969	3,144	58	3,202	3,209	69.9	16.0	7.7	3.8	.7	1.8	.1	2,863	14.3
1970 4/	3,400	65	3,465	3,465	70.7	15.9	7.2	3.8	.4	1.9	.1	3,075	15,0

1/ Data not available prior to 1959.
2/ Includes salad and cooking oils processed for export.
3/ Olive oil.
4/ Preliminary — based on data through November.

Source: USDA; Economic Research Service; Fats and Oils

fried snack foods, mellorine, bakery food mixes, confectionery fats, toppings, milk fillings, and other specialty fats. In 1970, salad and cooking oils comprised roughly 28 percent of total food fats and oils consumed in the United States, compared with 16 percent some 20 years earlier.

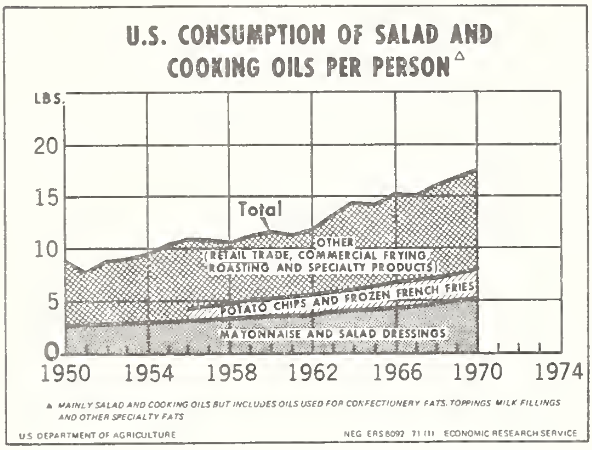

Chart 10

Salad and cooking oils are made from vegetable oils that are usually refined, bleached, deodorized, and sometimes lightly hydrogenated. Soybean oil is the leading oil sold in this form, and its relative importance continues to increase. In 1950, soybean oil accounted for about 28 percent of all oils used in salad and cooking oils, but in 1970 the proportion had increased to over 70 percent. Cottonseed oil usage during the same period slipped from around 43 percent to 16 percent. Corn, peanut, safflower, and olive oil are also used, but their share of the total market gained only slightly.

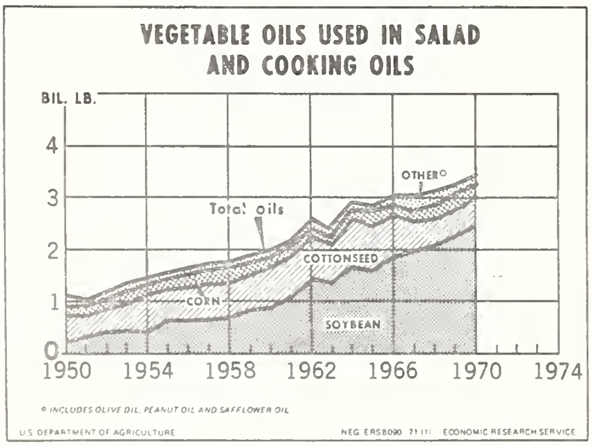

Chart 11

COOKING FAT USAGE STEADY OVER THE YEARS

During the past two decades, the annual consumption of cooking fats (direct use of lard plus shortening) has been fairly stable, averaging about 21 to 22 pounds per person. However, the direct use of lard (that used in the home, in bakeries, and in commercial and other institutions) trended downward — from 12 pounds in 1950 to less than 5 pounds in 1970. But this decline has been nearly offset by increased consumption of prepared shortenings — from 11 pounds to 18 pounds. Cooking fats represent about 43 percent of total domestic food-fat usage.

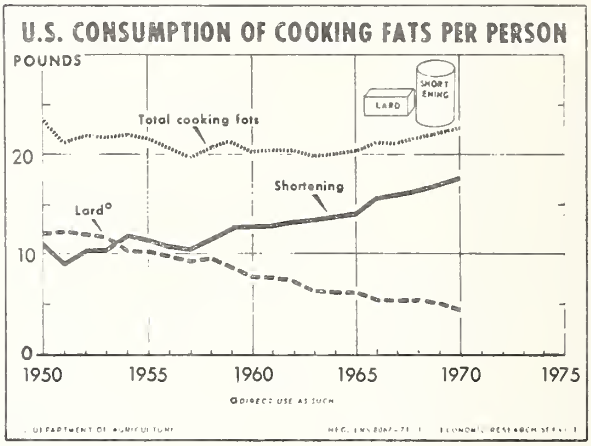

Chart 12

The population shift from agricultural to urban areas, and the changing structure of agriculture, have been major factors in the declining production and consumption of lard as such. Farm output of lard has declined steadily, from 300 million in 1950 to less than 25 million in 1970. Also, changes in shortening manufacturing techniques and consumer preferences have affected the competitive nature of the cooking fats industry. Most of the growth in shortening consumption can be traced to the substitution of shortening for lard in cooking uses. Some of the lard formerly consumed directly is now being blended with other animal fats and mixtures of animal and vegetable fats in hydrogenated shortenings. In recent years, about two-thirds of the shortenings produced were all vegetable oil, and the other third, 100-percent animal fat or blends.

Table 5. Shortening: U. S. production, fats and oils used in manufacture, and domestic consumption, 1950–70

Calendar year	Shortening production	Fats and oils consumed in shortening manufacture									Shortening domestic consumption (civilian)	
		Total fats and oils	Edible vegetable oils (% of total)					Animal fats (% of total)				
			Soybean	Cottonseed	Palm	Coconut	Total 1/	Lard	Beef fats	Total	Total	Per capita
	Mil. lb.	Mil. lb.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Mil. lb.	Lb.
1950	1,710	1,727	48.7	31.8	---	---	88.0	10.2	1.8	12.0	1,656	11.0
1951	1,403	1,405	52.0	23.8	---	1.4	84.1	14.2	1.7	15.9	1,365	9.0
1952	1,611	1,613	52.8	24.1	---	2.0	83.5	14.4	2.1	16.5	1,562	10.2
1953	1,675	1,681	53.7	22.4	---	.1	83.7	13.5	2.8	16.3	1,597	10.2
1954	1,961	1,969	46.6	32.5	---	.8	88.2	7.2	4.6	11.8	1,870	11.8
1955	1,975	1,988	46.8	22.1	---	.2	77.3	16.8	5.9	22.7	1,863	11.5
1956	1,842	1,855	42.2	17.4	---	.3	67.7	24.7	7.6	32.3	1,797	10.9
1957	1,808	1,824	43.6	14.9	---	.4	66.9	20.6	12.5	33.1	1,756	10.4
1958	2,006	2,011	52.5	11.9	---	.6	71.7	15.8	12.5	28.3	1,935	11.3
1959	2,252	2,244	50.9	14.3	---	.9	66.6	22.0	11.4	33.4	2,196	12.6
1960	2,313	2,302	50.8	15.9	---	.4	67.5	20.9	11.6	32.5	2,238	12.6
1961	2,456	2,459	47.2	14.5	.4	1.1	64.3	21.6	14.1	35.7	2,311	12.8
1962	2,689	2,696	50.5	13.6	.6	1.0	66.3	21.2	12.5	33.7	2,469	13.4
1963	2,584	2,611	47.0	12.6	.5	.7	61.5	22.7	15.8	38.5	2,525	13.5
1964	2,664	2,693	51.5	14.0	.4	.7	67.5	16.5	16.0	32.5	2,598	13.7
1965	2,792	2,768	53.1	14.6	.5	.7	69.5	16.5	14.0	30.5	2,695	14.0
1966	3,181	3,192	54.3	11.6	1.2	1.2	69.2	15.4	15.4	30.8	3,079	15.9
1967	3,226	3,243	53.7	8.4	1.9	1.2	66.6	17.8	15.6	33.4	3,108	15.9
1968	3,312	3,326	55.4	7.5	2.2	1.2	67.3	18.1	14.6	32.7	3,211	16.2
1969	3,481	3,489	59.8	7.1	3.2	1.4	72.5	13.6	13.9	27.5	3,398	17.0
1970 2/	3,700	3,710	62.0	8.5	2.2	1.1	74.8	10.8	14.4	25.2	3.625	17.9

1/ Includes small quantities of peanut oil, corn oil, safflower oil, vegetable stearine and glycerides, not shown separately.
2/ Preliminary — based on data through November.

Source: USDA; Economic Research Service; Fats and Oils

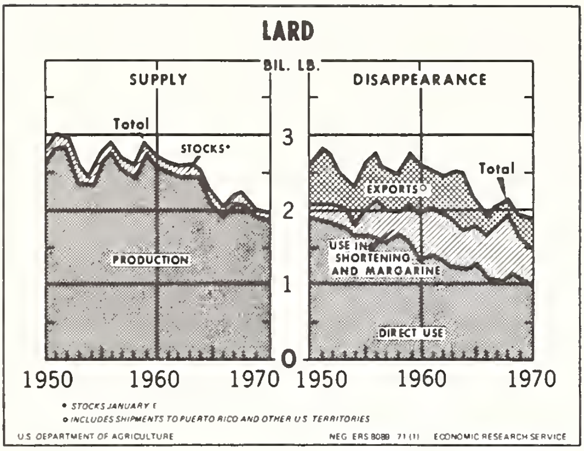

Chart 13

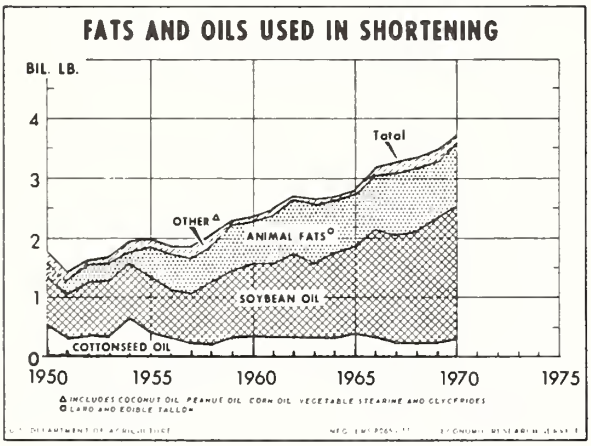

Chart 14

INCREASED CONSUMPTION OF MARGARINE OFFSETS DECLINE IN BUTTER

For many years, U.S. consumers have been shifting away from butter to margarine as a table spread. This changed consumption pattern is attributed to the substantial price difference between the two products, the repeal of anti-margarine laws, the popularization of margarine use during World War II, and improvements in the formulation and qualities of margarine. Wholesale butter prices usually have been at least double those for margarine. In 1970, the ratio was about 3 to 1.

During the past 20 years, the annual per capita consumption of table spreads has remained relatively steady, averaging 16 to 17 pounds. (This rate represents a fat use of 13 to 14 pounds because the fat content of butter and margarine are roughly 80 percent of total weight). These products currently comprise about 24 percent of total U.S. food-fat consumption. Increased use of margarine has about offset the decline in butter.

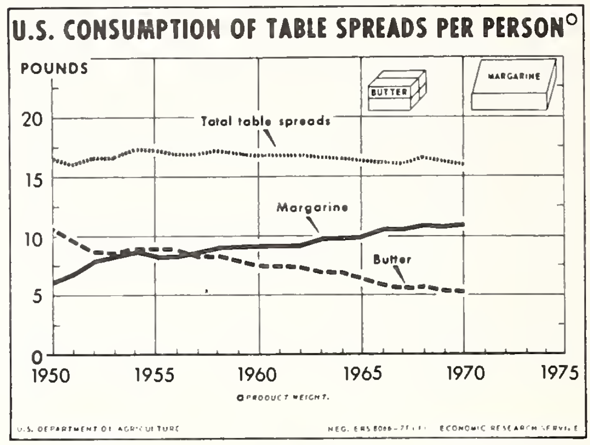

Chart 15

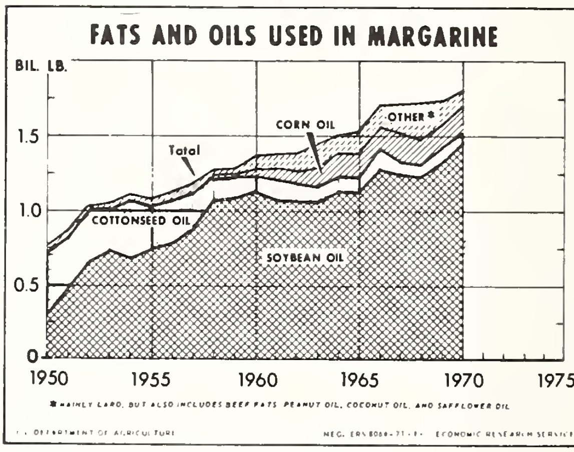

Chart 16

Margarine consumption has risen steadily from 6 pounds (product weight) per person in 1950 to a record 11 pounds in 1970. Margarine consumption last year was twice as great as butter consumption (5 pounds), whereas 20 years ago, butter usage was about 5 pounds greater than margarine.

Increased production and consumption of margarine were made possible by the sharp growth in domestic output of edible vegetable oils — mainly soybean oil. Expanding supply has meant lower prices in recent years for the fats and oils ingredients used in the manufacture of margarine. One of the most significant developments in recent years has been the sharp expansion in the use of corn and safflower oils as a margarine ingredient along with increased production of "soft" margarines.

FUTURE PROSPECTS

Domestic use of food fats and oils is expected to continue to increase a little faster than the growth in population. Per capita disappearance is projected to increase slightly in

Table 6. Margarine: U. S. production, fats and oils used in manufacture, and domestic consumption 1950–70

Calendar year	Margarine production (actual weight)	Fats and oils consumed in margarine manufacture									Margarine domestic consumption (civilian)		
		Total	Edible vegetable oils (% of total)					Animal fats (% of total)			Total (actual weight)	Per capita	
			Soybean	Cotton-seed	Corn	Saf-flower	Total 1/	Lard	Beef fats	Total		Actual weight	Fat content
	Mil. lb.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Mil.lb.	Lb.	Lb.
1950	937	764	40.8	54.7	.1	---	98.3	0.5	1.2	1.7	918	6.1	4.9
1951	1,041	851	56.2	39.2	1.9	---	98.8	.5	0.8	1.2	906	6.6	5.3
1952	1,286	1,046	62.3	33.8	2/	---	98.8	.5	.8	1.2	1,219	7.9	6.4
1953	1,292	1,049	69.2	26.2	.1	---	98.0	.8	1.2	2.0	1,256	8.1	6.5
1954	1,364	1,106	60.1	35.9	2/	---	98.5	.6	.9	1.5	1,346	8.5	6.9
1955	1,334	1,075	69.4	25.9	2/	---	98.0	1.2	.8	2.0	1,323	8.2	6.6
1956	1,370	1,111	65.9	25.5	.1	---	96.7	2.8	.5	3.3	1,354	8.2	6.6
1957	1,463	1,182	73.9	20.1	2/	---	97.0	2.2	.8	3.0	1,446	8.6	6.9
1958	1,573	1,269	84.3	11.4	.1	---	98.1	1.3	.6	1.9	1,549	9.0	7.3
1959	1,611	1,291	84.7	9.6	1.5	---	96.7	2.8	.6	3.3	1,604	9.2	7.4
1960	1,695	1,367	80.8	9.9	4.0	---	95.5	4.1	.4	4.5	1,676	9.4	7.6
1961	1,724	1,386	76.6	10.0	6.4	---	94.3	5.2	.4	5.7	1,708	9.4	7.6
1962	1,726	1,394	75.9	7.6	7.1	.4	94.3	5.0	.7	5.7	1,709	9.3	7.5
1963	1,794	1,451	72.3	7.2	9.4	1.5	93.4	5.8	.8	6.6	1,785	9.6	7.7
1964	1,857	1,500	75.9	6.7	10.0	.8	94.9	4.3	.9	5.1	1,835	9.7	7.8
1965	1,904	1,535	72.4	7.4	10.5	.7	92.5	6.5	.9	7.5	1,891	9.9	7.9
1966	2,110	1,710	75.7	6.2	9.2	2.7	94.9	4.8	.3	5.1	2,038	10.5	8.5
1967	2,114	1,703	73.3	4.6	10.3	2.5	92.1	7.3	.6	7.9	2,046	10.5	8.4
1968	2,141	1,720	72.1	4.1	10.4	2.4	90.2	8.9	.9	9.8	2,130	10.8	8.7
1969	2,182	1,743	76.5	4.4	9.9	2.5	94.4	4.9	.7	5.6	2,154	10.8	8.6
1970 3/	2,225	1,800	80.5	3.8	10.1	1.2	96.4	3.2	.4	3.6	2,215	11.0	8.8

1/ Includes small quantities of peanut oil, coconut oil, and vegetable stearine that are not shown separately.
2/ Less than .05 percent.
3/ Preliminary — based on data through November.

Source: USDA; Economic Research Service; Fats and Oils

Table 7. Selected characteristics relating to the production of salad and cooking oils, shortening and margarine, 1956–70

Calendar year	Salad and cooking oil production: Total	Soybean		Other		Shortening production: Total	100% vegetable oil		100% animal fat or blends	
	Mil. lb.	Mil. lb.	Pct.	Mil. lb.	Pct.	Mil. lb.	Mil. lb.	Pct.	Mil. lb.	Pct.
1959	1,808					2,252				
1960	1,915					2,313				
1961	2,124	1/	1/	1/	1/	2,456				
1962	2,532	1,434	56.6	1,098	43.4	2,689				
1963	2,359	1,315	55.7	1,045	44.3	2,584				
1964	2,846	1,633	57.4	1,213	42.6	2,664	1/	1/	1/	1/
1965	2,773	1,554	56.0	1,219	44.0	2,792	1,852	66.3	940	33.7
1966	2,947	1,854	62.9	1,092	37.1	3,181	2,113	66.4	1,068	33.6
1967	2,922	1,897	64.9	1,025	35.1	3,226	2,077	64.4	1,149	35.6
1968	2,996	2,022	67.5	974	32.5	3,312	2,139	64.6	1,173	35.4
1969	3,144	2,230	70.9	914	29.1	3,481	2,318	66.6	1,163	33.4
1970 2/	3,400	2,450	72.0	950	28.0	3,700	2,475	66.9	1,225	33.1

Margarine production (Product weight)

Calendar year	Total production	Packaged: One pound units: Soft	One pound units: Other	One pound units: Total: Volume	One pound units: Total: Pct. of total packaged	All other consumer-sale unit (including country pats)	Individual servings (chips)	Bakery or industrial (over one pound)	Total packaged 3/: Volume	Total packaged 3/: Pct. of total production
	Mil. lb.	Mil. lb.	Mil. lb.	Mil. lb.	Pct.	Mil. lb.	Mil. lb.	Mil. lb.	Mil. lb.	Pct.
1956	1,370			1/						
1957	1,463			1,363						
1958	1,573			1,464						
1959	1,611			1,485						
1960	1,695			1,556						
1961	1,724			1,583						
1962	1,726			1,578						
1963	1,794			1,632						
1964	1,857			1,679						
1965	1,904			1,726	1/	1/	1/	1/	1/	1/
1966	2,110			1,882	89.1	55	27	149	2,113	100.1
1967	2,114	1/	1/	1,859	87.2	79	28	176	2,133	100.9
1968	2,141	282	1,616	1,898	86.8	59	21	172	2,150	100.4
1969	2,182	356	1,589	1,945	88.7	54	21	173	2,193	100.5
1970 2/	2,225	415	1,560	1,975	88.8	50	21	179	2,225	100.0

1/ Data not available for earlier years. 2/ Preliminary — based on data through November. 3/ The sum of margarine packaged by package sizes may not agree with the total production because some margarine is not packaged during the same month in which it is produced.

Source: USDA; Economic Research Service; Fats and Oils

the next decade, possibly by 2 to 5 pounds (fat content) from 53 pounds in 1970. The shift from animal fats to edible vegetable oils is expected to continue.

The fast-food industry likely will continue expanding, and this means increased demand for edible oils. One trade report predicts the marketing and franchising system will increase 30 percent in the next 5 years, and that by 1975 there will be more meals eaten away from home than at home. And the frozen, pre-fried product will become a major item, not only in the food service field, but in the supermarkets. Soybean oil likely will benefit most from the broader market for edible oils, as the expanding demand for soybean meal will also help to stimulate production of soybeans and oil and keep soybean oil in a favorable competitive position.

SESSION II: Ralph C. Woodruff, The Delta Products Co., Wilson, Ark., Chairman

THE AFLATOXIN PROBLEM — BACKGROUND

by
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The discovery of aflatoxin has all the elements of a good scientific murder mystery. I am not going to try to tell that story, but picture for yourself the death of more than 100,000 young turkeys in a period of just a few months from what appeared to be an unknown disease, all within a radius of about 100 miles from London. It was called the "Turkey-X-Disease," X being the unknown. That was in the summer of 1960. About the same time, there were reports of deaths of thousands of young ducks and pheasants, again in the same vicinity and from unknown causes.

Veterinarians and scientists of all kinds — pathologists, microbiologists, nutritionists, chemists, and others, were called to seek a solution. But in an intensive investigation, everything they found was negative. It was not any of about 50 known chemical poisons.

It was not a plant poison such as an alkaloid. They could not find any virus or bacterial infection or any new micro-organism. Eventually, the toxicity was traced to the feed, and more specifically, to one ingredient in the feed. That was a peanut meal that had been imported from Brazil. It was given the name "Rossetti meal" from the name of the ship that had brought it to England, and there were thousands of tons of it. About this time, it was found that ducklings that had eaten peanut meal on farms in East Africa had died from a similar cause. That was the first indication that not only Brazilian peanut meal could cause this disease.

The discovery that the deaths were caused by the Rossetti meal narrowed the problem. After much concentrated effort on the part of a number of scientists in different disciplines, it was found that the toxicity was, in fact, due to a chemical. But it was a very unusual kind of chemical, one produced by a mold and one that nobody had ever heard of before. Antibiotics such as penicillin are chemicals produced by molds, and this was a chemical produced by the very common mold, Aspergillus flavus.

A flavus is ubiquitous. It may be found almost anywhere, so it was not too surprising that ducklings that had eaten peanut meal on farms in East Africa had died with the same disease as the ducklings in England that had died from eating the Rossetti meal. Procedures were soon developed for extracting the toxic material from the meal and for concentrating it. The toxic material was named aflatoxin from the words Aspergillus FLAvus TOXIN.

A chemical test was devised for recognizing aflatoxin in extremely small amounts. This test was based on observation of a characteristic bluish fluorescence that could be seen when partly purified extracts were illuminated with ultraviolet light. By this test, as little as one-tenth of a microgram could be detected; that is about one-billionth of an ounce. Let us note again that it is not the mold itself that is the toxin; the toxin is a chemical produced by a mold. The mold may be dead, but the chemical will still be there.

About this time (late in 1961), it was found that if Rossetti meal were fed to rats for a long time, they developed cancer. That made it another game and aroused more interest in aflatoxin. Now we have a striking coincidence. In April 1960, a shipment of live rainbow trout from a commercial fish hatchery in Idaho was stopped for a routine inspection at a fish-disease checking station at the California border. It was found that many of the trout had hepatomas, liver cancer. The cause was eventually attributed to aflatoxin, but this time it was presumably derived from a cottonseed meal in the feed. And still more scientific interest in aflatoxin was generated.

As you know, science is never static; things have a way of multiplying. We now know that aflatoxin may be produced not just by

Aspergillus flavus on peanuts and cottonseed, but in greater or lesser amounts by several different species of molds and on just about any food or feedstuff — corn, wheat, soybeans, sorghum, rice, you name it — whenever warm and moist conditions combine to produce circumstances conducive to fungal growth. And there is not just one aflatoxin; there is a whole family of closely related chemical compounds.

First, there was one, and then there were two. These were named aflatoxin B and aflatoxin G because one appeared to be Blue and the other Green under ultraviolet illumination. You will recall that the original chemical test was based on observation of a characteristic blue color. Then, as chemical methodology was improved, it was recognized that Aflatoxin B was really a mixture of two very closely related chemicals, and so was aflatoxin G. Now, we had four, and these were called aflatoxin B_1, B_2, G_1,, and G_2. Both of the B's were blue, the G's green. The "2's" did not move quite as fast as the "1's" in a particular method of examination.

That brings us up to about 1964, when it was found that if dairy cattle are fed rations that contain large amounts of aflatoxin, a new toxin is found in the milk. It turned out that this is a very simple chemical derivative of Aflatoxin B_1. Although it also can be produced by some strains of mold, it was given the name aflatoxin M to indicate that it was first recognized in Milk. Only a small proportion of the aflatoxin B_1 that is ingested, about 1 percent, is converted to aflatoxin M. But extremely sensitive chemical methods have been developed for detecting these aflatoxins. Under favorable circumstances, they can be detected at levels distinctly below one part per billion (p.p.b.). That is an extremely small amount. It has been expressed on a time scale in this way: one second in 32 years is equivalent to 1 p.p.b.

This morning, with Shepard and Mitchell walking on the surface of the moon at this very moment, a distance scale might be more appropriate. The distance from the earth to the moon is a little more than 200,000 miles. One billionth of that distance is about 1 foot, 1 p.p.b. Or, put it this way: if you were to add one jigger of vermouth to a standard tank car of gin, you should have a very dry martini and about one part per million. Divide that one jigger among a thousand tank cars, and you would have about one part per billion. And that is the order of magnitude with which we are dealing.

As of early 1971, there were a dozen different chemical compounds that have been named "aflatoxin". There are B_1 and B_2, G_1 and G_2; there are M_1 and M_2, and B_{2a}, and G_{2a}, and B, and still others. B_1 is the most plentiful and is the one that is generally produced in largest amount. Most work has been done on aflatoxin B_1, which is the most toxic. All the aflatoxins are very closely related chemically but they may differ tremendously in their biological effects.

Toxicity depends not only on the aflatoxin, but also on the animal species. In all cases, the young are most readily affected. The duckling is the most sensitive. But feeding young ducklings aflatoxin B_{2a} in an amount 50 to 100 times the amount of B_1 that would kill them appears to have no adverse effect. Thus, we have a difference of at least 100-fold in the toxicity of these two very closely related aflatoxins. Aflatoxin M seems to be about as toxic as aflatoxin B_1. As you know from the Turkey-X-Disease, turkeys are also very sensitive to aflatoxin. Sheep seem to be the most resistant of farm animals. The mouse, unlike the rat, is also very resistent.

Some of the aflatoxins are highly carcinogenic for some animal species. Again, the one that is most toxic, aflatoxin B_1, is also the most carcinogenic. Aflatoxin M is also carcinogenic. The rainbow trout appears to be the most sensitive in this respect, and hepatomas develop at dietary levels of about 2 or even less p.p.b. of aflatoxin B_1. That should easily qualify aflatoxin B_1 as the most potent, known carcinogen for rainbow trout, but closely related species of trout are far more resistant. For the rat, it has been reported that a dietary level of 15 p.p.b. of aflatoxin B_1 resulted in 100-percent incidence of hepatomas after about a year and a half. It was estimated that each animal had ingested only about one-tenth of a milligram of aflatoxin B_1 — a few millionths of an ounce. But in mice, nobody has yet been able to induce cancer by means of aflatoxin, even though far larger amounts have been tested.

Before we leave the subject of carcinogenicity, I want to emphasize that as of now, there have been no reports of tumor induction in primates by aflatoxin — and that includes man. I should also like to quote from a paper by Lancaster, the senior author of the first report on the carcinogenicity of the Rossetti meal. He wrote: "At present the extent of individual species variation in metabolism is so great that no significant prediction of toxicity can be made for another species. In man, an association of liver tumors with aflatoxin may occur, but to date no such association can be made." It may be that man, like the mouse, is highly resistant to both the toxic and carcinogenic effect of aflatoxin.

Now, with that reassuring note, one last thought. Tremendous scientific interest has developed in the aflatoxins. There are now more than two thousand scientific publications dealing with aflatoxin. I have mentioned that a dozen aflatoxins were recognised during the past

few years. The development of their chemistry in so short a time is one of the triumphs in the history of structural organic chemistry of natural products. There is very great interest in all kinds of mycotoxins (mold toxins). There is now the same kind of scientific interest in mycotoxins as there was some 50 years ago in vitamins. At that time, we began to be aware of illnesses caused by absence from the diet of trace amounts of previously unrecognized materials called vitamins. Now we are dealing with illnesses caused by presence in the diet of trace amounts of previously unrecognized materials called mycotoxins. Since it is their presence that we want to avoid, it would appear that prevention would be the best method to accomplish this objective. And that is the subject of the next paper.

PREVENTION OF AFLATOXINS IN COTTONSEED

by
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Results of experiments made in California between 1965 and 1969 show that the aflatoxin problem of cottonseed is the result of seed infection that occurs in the field. It does not appear to be a problem that originates in storage, nor does it appear to be aggravated there. That is, results of our tests indicate that seed, with regard to aflatoxins, comes out of storage in about the same condition that it goes into storage. Details of a study which justifies the previous statements are in a paper now in press in the Journal of the American Oil Chemists' Society.

Prevention of aflatoxins in cottonseed, then, means preventing or escaping a disease of lint and seed which originates in the field. Escape from infection, either by natural or contrived means, appears to be a better avenue for control than one of protection with fungicides. In the latter case, neither results of tests with protective nor systemic-acting fungicides have been promising. In addition, fungicides pose another built-in problem, namely the possibility of residues in food and feedstuffs.

Natural escape from infection can be near absolute. This phenomenon explains the essential absence of aflatoxins in the San Joaquin Valley of California. Absence of the problem is not due to lack of the fungus, Aspergillus flavus, because it is equally common in soils of both the San Joaquin and Imperial Valleys. Instead, we found that nearly all bolls escape infection in the San Joaquin Valley, because they open and dry too quickly for the fungus to become established. On the other hand, bolls of plants in the Imperial Valley are prevented from opening and drying quickly because of the high moisture content of the air. Therefore, seeds are prone to infection for an extended period of time.

In the San Joaquin Valley, bolls reach air dryness within 30 to 40 hours, whereas bolls on plants in the Imperial Valley require about 150 hours on the average. But more important, about 12 percent of the bolls of plants in the Imperial Valley never fully open. Results of our tests show that seeds with high concentrations of aflatoxins come from such bolls. The validity of these remarks has been verified in field experiments in the San Joaquin Valley, in which the atmospheric moisture content of air surrounding plants was adjusted with a water mist system.

These observations appear to explain why aflatoxins are a problem in cottonseed of southern California, Arizona, and perhaps portions of New Mexico, Texas, and Oklahoma. However, there is no reason to think that they explain the near absence of affected cottonseed in the rain-belt area of the United States, which like the San Joaquin Valley, appears to be affected very little by the problem. To my knowledge, near absence of aflatoxins in rain-belt cottonseed is an unexplained anomaly, since peanuts grown in that region appear to be affected with the problem.

Nevertheless, the observations made in California can be used there and in similar regions to describe a situation in which most bolls will escape infection from A. flavus. Basically, it involves altering the atmospheric environment of the lower part of the cotton plant, where most infections occur, so that maturing bolls will open and dry quickly. Two approaches, neither innovations on our part, have been used. Chemically induced defoliation of the lowermost one-third part of plants reduced infection about 50 percent below that observed in solid-planted cotton fields. A 4 by 4, skip-row planting pattern reduced infections and aflatoxins about 70 to 90 percent below the amounts observed in nondefoliated solid plantings in 10 tests made in 1967. These results support those of a single experiment made in 1966. In uncomplicated situations, then, the practices just described appear adequate for control of the problem. Their success depends

upon harvest before mature lint and seed have been wet by rain. The preceding remarks on epidemiology and control of infection from A. flavus are published in the Journal of Stored Products Research.

The threat of rain was the only factor complicating satisfactory control of the aflatoxin problem in California until 1968. However, in this year, the situation was dramatically changed when the pink bollworm became distributed thoroughly in the southern desert valley. Whereas on the average unweathered seedlots contained less than 20 p.p.b. aflatoxins since that time. The data on pink bollworm and aflatoxins are in press in Phytopathology. This is how it works:

Adult female moths oviposit under the calyces of young bolls, and soon the first instar larvae from the eggs burrow through the wall of the boll and enter locules to feed. After about 12 days, they burrow out, drop to the ground, and pupate to produce more adults. The first instar larvae are very small. In our tests, their tunnels did not provide an avenue of entry to locules for A. flavus. The merging larvae, however, are considerably larger than the first instar larvae, and they leave good-sized openings. the openings left by emerging larvae are very important avenues of entry for A. flavus, as well as for other boll-rotting fungi. As mentioned earlier, the average maturing boll reached air dryness in about 150 hours or 4 days, in absence of this pest, but the presence of exit holes increased the length of time that bolls are prone to infection to 35 or more days. Thus, the dramatic increase in aflatoxins that we have regularly observed since 1968.

Experiments were made in the field to determine how many pink bollworms were necessary to be a serious pest with regard to fungal infections and aflatoxins. Control bolls (5 to 7 days old) were bagged to prevent infestation by the pink bollworm. Other bolls (also 5 to 7 days old) were infested with two and 10 eggs, and then bagged to prevent further infestation. Bolls were allowed to mature in muslin bags. They were not inoculated with A. flavus; instead, only infections from native inoculum took place. At maturity, in absence of the pink bollworm, seed contained a mean of 12 p.p.b. aflatoxins. In contrast, seed from bolls infested with two eggs contained 1,900 p.p.b aflatoxins, and seed from bolls infested with 10 eggs containing 5,300 p.p.b. aflatoxins.

A further complication is presented by other bollrotting fungi, principally Rhizopus sp. and Aspergillus niger. Like A. flavus, these fungi cannot penetrate the outer walls of bolls, but once established on lint, via exit holes of larvae, they attack the inner walls of bolls. This induces necrosis and premature separation of carpels. The influence of other fungi upon infection from A. flavus was determined. The results follow: Immature bolls, free from carpel necrosis caused by Rhizopus sp. or A. niger, had 4 percent of the locules infected by A. flavus. But immature bolls with carpel necrosis had 18 percent of their locules infected with A. flavus. In mature bolls, those with carpel necrosis had 23 and 47 percent of the locules, respectively, infected with A. flavus. Is it surprising, then, that we see 2,000 p.p.b. aflatoxins instead of the 20 p.p.b. that we observed in 1965 and 1966? I don't think so.

Obviously, the pink bollworm must be controlled, but how can this be done? Two things seem certain. It will not be done solely with insecticides, and it is not likely to be done with a sterile adult moth program. Thus far, these programs have induced little or no response, as in the case of sterile moths, or they have contributed to development of new problems, as in the case of insecticides. In the latter case, repeated applications of insecticides in numerous instances have brought on a lethal pest, the cotton leaf perforator. Entomologists believe that there is a solution. It is not new, and it works for a very simple biological reason. The life cycle of the insect must be broken, and the method for breaking it is at hand.

The key to control of the pink bollworm lies in stopping growth of the cotton plant before a significant portion of the insect population diapauses. In California, this occurs about September 15. Stopping plant growth, by defoliation, allows fewer than 10 percent of the insects to be in a position to overwinter. Area-wide use of this practice, coupled with judicious use of insecticides, has resulted in excellent control of the pest in parts of Arizona, and unpublished results indicate that it also has, as expected, dramatically reduced the aflatoxin content of seeds. This type of program was begun in the Blythe area of California in 1970, and it appears that Imperial Valley growers, after repeated disasters, have begun to accept the idea. It seems imperative that San Joaquin Valley growers also come to terms with the problem, now that the pink bollworm appears to have reproduced in the vicinity of Bakersfield, Calif. It would be a tragedy to allow this area, where about 90 percent of California cotton is grown, to suffer the fate of the southern desert valleys.

REMOVAL AND INACTIVATION OF AFLATOXIN FROM CONTAMINATED OILSEEDS AND OILSEED MEAL

by
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I wish to highlight and summarize research results at SMNRD on the removal and inactiviation of aflatoxin from contaminated cottonseed meal. This includes a wide range of materials. What I will report is also applicable to the peanut aflatoxin problem, especially in treatment of contaminated peanut meal. Many publications, and some manuscripts in preparation, cover the results of our Division research on removal and inactivation of aflatoxin from contaminated cottonseed and peanuts.

In his abstract for the program of this meeting, L. A. Goldblatt cited levels below 20 parts per billion (p.p.b.) total aflatoxin are called for in current Food and Drug Administration (FDA) Guidelines — that is, routine regulatory actions would result when concentrations above 20 p.p.b. are found. Hence, in our research efforts, our goal has been reduction of aflatoxin to levels well below 20 p.p.b. in processing aflatoxin-contaminated oilseeds.

Do you realize how small one part in a billion is? It is equivalent to:

About 15 inches in 238,857 miles.

238,857 miles is an average distance of the earth from the moon.

15 inches is one small step.

Remember Armstrong saying, as he reached the moon's surface in July 1969! "One small step for man, one giant leap for mankind." This comparison is particularly applicable today. Shepherd and Mitchell are walking on the moon now!

Research results that reduce contamination with aflatoxin in cottonseed and cottonseed meals from hundreds of p.p.b. to a nondetectable level up to 6 p.p.b. achieve a giant leap forward toward solution of this problem in certain segments of the oilseed industry.

Inactivation. Mann, Codifer, Gardner, Koltun, and Dollear, in a publication entitled "Chemical Inactivation of Aflatoxin in Peanut and Cottonseed Meal" report:

(a) The rate of aflatoxin destruction in contaminated cottonseed meal by a heat treatment at 100° C. for a range of moisture from 6 to 30 percent, and up to 2 1/2 hours. The most severe treatment (100° C., 30 percent H_2O, 2 1/2 hours) reduces the aflatoxin level from 144 p.p.b. of B_1 to about 20 p.p.b.

(b) Over 60 chemical treatments were evaluated using a similar heat treatment in conjunction with chemical reagents.

Results revealed that certain treatments, particularly alkali treatments, showed promise for achieving aflatoxin inactivation.

Of all the chemical treatments studied, ammoniation showed the best potential, and hence extensive work was carried out in laboratory, pilot plant, and with industry.

Tons of contaminated cottonseed meal have been successfully inactivated to levels of nondetectable to 3 to 6 p.p.b. Our research results on ammoniation of contaminated cottonseed and peanut meals for the inactivation of aflatoxin contamination are scheduled for publication in this month's issue of the Journal of the American Oil Chemists' Society (JAOCS). In their publication, Gardner, Koltun, Dollear, and Rayner establish the optimum conditions to achieve the desired reduction. They are: Treatment time — 30 minutes; ammonia pressure — 50# gauge; moisture — 12 to 14 percent, temperature — 210° to 250° F. With such treatment, a series of runs were made in large-scale equipment with the cooperation of industry, using cottonseed meal containing an average of 519 p.p.b. total aflatoxin. Aflatoxin content of this meal was reduced to below 5 p.p.b. and down to nondetectable levels.

With the assistance of our Western Division, FDA protocol was established, and necessary feeding tests with the ammonia-treated cottonseed meal are underway and planned as follows:

Rat — 2 year (commenced June 1970)
PER — underway
Trout Feeding Test — Scheduled to begin in May 1971.

Removal. Southern Marketing and Nutrition Research Division (SMNRD) has studied removal from two approaches: (1) physical separation, and (2) solvent extraction systems.

Physical separation. Some earlier work using a projection device looks promising for upgrading 80 to 85 percent of the seed to acceptable levels. This leaves 15 to 20 percent of the seed containing most of the contamination. To this end, a Zig-Zag separator has been purchased for future studies, and shipment is expected sometime in March.

Solvent extraction systems. Four processes have been studied for removal of aflatoxin from contaminated cottonseed or cottonseed meal. Two processes are for meats or flakes produced from cottonseed.

1. An acetone-hexane-water solvent

mixture to extract the prepared, flaked cottonseed. This includes research of Frampton, King, Gastrock, and others.

2. A two-stage extraction process — aqueous acetone (70-percent acetone: 30-percent water, by weight) extraction of prepared meats, followed by a second extraction with anhydrous acetone of hexane. This includes the research by Pons and Eaves.

3. Extraction of aflatoxin-contaminated cottonseed meal with aqueous acetone (90-percent acetone: 10-percent water, by weight) represents the work of Gardner, Koltun, and Rayner.

4. Extraction of the aflatoxin-contaminated cottonseed meal with aqueous isopropanol (either 80-percent isopropanol; 20-percent water, by weight, or azeotrope, which is 87.7 percent isopropanol and 12.3-percent water) as conducted by Dollear, Rayner, and Koltun.

For these processes, resulting products will be cited, and real, legal, and psychological advantages and disadvantages listed.

I. A-H-W Process. Consider two solvent mixtures. First, 39-percent acetone, 60-percent hexane, and 1-percent water, by weight, can be used in conventional extraction equipment with some modifications. Such a mixture will remove up to about 70 percent only of the aflatoxin in the contaminated cottonseed.

With a mixture of 54-percent acetone, 44-percent hexane, 2-percent-plus water as a heated solvent mixture, hardware other than conventional extraction equipment (such as shaker screens, press, cyclone, or centrifuge) will be needed. These conditions are capable of removing aflatoxin down to acceptable levels (from 320 p.p.b. to 3 p.p.b. total). The products from such an A-H-W extraction are:

Oil of good quality, if properly refined, that is, refined quickly or miscella refined;

Meal low in gossypol, CPA, extremely low in aflatoxin, good nutritional value (high EAF lysine);

Byproduct — soapstock — contains gossypol pigments, aflatoxin.

ADVANTAGES:

1. Meal has low, free, and total gossypol, acceptable aflatoxin level, low CPA content, high nutritional value. In addition, it has a very high protein solubility and EAF lysine; lipids are very low. Markets for this meal should be easy to find, because of its high quality.

2. Claim of increased oil yield — several pounds per ton of seed.

3. Good quality oil can be obtained if refined quickly — preferably by miscella refining. Small amounts of carbohydrates are extracted in the miscella.

4. Removal of aflatoxin leaves no derivatives.

DISADVANTAGES — REAL:

1. Little experience with process for removing aflatoxin.

2. Poor quality soapstock not suitable for feed use.

3. Requires new type of extraction equipment and handling of several solvents.

4. If intended for food use, "catty" odor and flavor problem of the meal needs solution. Impurities originally present in acetone and formed during processing impart objectionable flavors to many foods. Evidence indicates that the offensive "catty" odors are probably associated with trace amounts of diacetone alcohol and mesityl oxide reaction products.

DISADVANTAGES — LEGAL:

1. New process wil require FDA approval of oil and meal products.

2. Residual acetone in meal probably limited to 30 p.p.m. (based on FDA tolerance for spices).

3. Disposal of soapstock washings may be pollution problem.

4. FDA may require a trout feeding test of meal which would pose a limit of essentially zero tolerance.

DISADVANTAGES — PSYCHOLOGICAL:

Problem of selling a mixed solvent extraction process to cottonseed processors.

II. Two-stage extraction process. First stage aqueous acetone; second stage either anhydrous acetone or hexane to remove the oil. The products are:

Crude oil — has a refined oil color. It is low in free fatty acids, and may be easily miscella refined, if necessary.

Meal — is extremely low in aflatoxin, low in gossypol, has a high protein content (67 to 70 percent), high nitrogen solubility, and high lysine content.

Byproduct — produced by first-stage extraction with aqueous acetone — will be about 6 to 8 percent by weight of flaked meats. Consists of gossypol, aflatoxin, free fatty acids, raffinose (sugar), and small amounts of protein and oil.

ADVANTAGES:

1. Meal has a low gossypol content, and acceptable level of aflatoxin.

2. Protein content is high.

3. Protein quality is relatively high, that is, EAF lysine and nitrogen solubility are high.

4. Oil is low in free fatty acids content and its color is comparable to that of conventionally refined cottonseed oil.

5. Removal of aflatoxin leaves no derivatives.

DISADVANTAGES — REAL:

1. No pilot plant experience with process. Only laboratory work by Pons and Eaves, published in JAOCS.

2. Acetone is a poor extractant for oil, but commercial hexane can be used.

3. Oil probably will require further refining.

4. New extraction hardware will be required, or major modifications of existing equipment will be necessary.

5. Byproduct, 6 to 10 percent of original flakes, presents a disposal problem.

DISADVANTAGES — LEGAL:

Same as those stated for the A-H-W process. In addition, there will be more of a pollution problem than results from the A-H-W process.

DISADVANTAGES — PSYCHOLOGICAL:

Same as for A-H-W — new process.

III. Solvent extraction process. — Aqueous acetone extraction (90-percent acetone, 10-percent H_2O, by weight). The products are:

Cottonseed meal — has an acceptable level of aflatoxin, can be as low as 3 to 6 p.p.b.

Byproduct — 3- to 5-percent solid of original meal weight; consists of sugars, aflatoxin, some gossypol, and small quantities of protein and oil.

ADVANTAGES:

1. Meal has a very low aflatoxin content (2 to 6 p.p.b. total).

2. Conventional extraction equipment can be used, such as certain types of shallow bed extractors.

3. Removal of aflatoxin leaves no derivatives.

4. Process removes additional gossypol and oil. It seems to have very little effect on lysine and the PER value of the meal. (However, nitrogen solubility is lower — reduced from 68 to 45 percent.)

DISADVANTAGES — REAL:

1. Requires additional equipment to conduct reextraction — essentially a complete solvent-extraction plant.

2. Byproduct of 3- to 5-percent solids presents a disposal problem.

3. Extraction facility could be idle, if aflatoxin problem was at a minimum in any particular crop year.

DISADVANTAGES — LEGAL:

1. New process will probably require FDA approval of product. Probably, trout-feeding tests will be required.

2. Residual acetone in meal probably limited to 30 p.p.m. (based on FDA limit for spices).

3. Disposal of byproduct may be a pollution problem.

DISADVANTAGES — PSYCHOLOGICAL:

Addition of another solvent step may be hard to sell to management.

IV. Isopropanol extraction process. — A solution of 87.7-percent alcohol and 12.2-percent H_2O, by weight, has been used. In addition, research with a solution of 80-percent isopropanol and 2-percent H_2O, by weight, was also studied. The products are:

Cottonseed meal — has an aflatoxin content as low as 3 p.p.b.

Byproduct — 9- to 10-percent solids (consisting of sugars, aflatoxin, some gossypol, and small quantities of oil and protein) with an 80- to 20-percent solvent mixture. However, with an 87.7- to 12.3-percent mixture, byproduct formation can be cut down to 5 to 7 percent.

ADVANTAGES:

1. Meal containing only 3 p.p.b. aflatoxin can be produced.

2. Removes aflatoxin, gossypol, lipids. Essentially, no effect on lysine content and preliminary PER determinations (but does reduce nitrogen solubility from 68 to 32 percent).

3. Isopropanol has been approved by FDA as an extraction solvent for whole-fish protein concentrates.

4. Removal of aflatoxin leaves no derivatives.

5. Some conventional-type extractor systems can be used.

DISADVANTAGES — REAL:

1. Requires additional extraction equipment. Essentially, a second extraction system.

2. Byproducts, from 5 to 7 percent of the weight of the contaminated meal, represents a disposal problem.

3. Extraction facility could be idle if aflatoxin problem was minimum in any particular year.

DISADVANTAGES — LEGAL:

1. New process, will require FDA approval of product. Trout-feeding tests might be required.

2. Residual isopropanol content in meal probably limited to 250 p.p.m., based on limit for whole-fish protein concentrate.

DISADVANTAGE — PSYCHOLOGICAL:

Addition of another solvent-extraction process is hard to sell to management.

In the interest of brevity, inactivation of aflatoxin in contaminated cottonseed meal by the ammoniation process is summarized here, outlining the advantages and disadvantages.

ADVANTAGES:

1. Applicable for treatment of meals from all types of crushing plants — screw press or solvent (hexane).

2. Less equipment is required.

3. No byproduct; hence, no real pollution problem.

4. Less expensive than solvent extraction for removal of aflatoxin.

DISADVANTAGE — REAL:

1. Will probably have to be a batch operation.

2. Seems to have some effect on protein quality. There is a reduction in EAF lysine and in PER's.

3. The ammoniated product would be limited to feeding ruminants.

4. Process leaves a chemical derivative that is a product from inactivation of aflatoxin.

DISADVANTAGES — LEGAL:

1. Requires FDA approval and feeding tests — probably trout-feeding tests.

DISADVANTAGES — PSYCHOLOGICAL:

Not equal to solvent approach — might be easier to sell to management if approved for use.

Cost of processes. — Now let us consider the cost, taking into consideration quality of products produced. No single process of the five discussed today — ammoniation for inactivation and the four solvent extraction processes — has every desirable advantage over the other four.

From the standpoint of initial investment (approximate figures), on a 212-ton cottonseed per day (24 hours) basis:

1. Installation costs for the ammoniation process would be about $200,000 for processing 100 tons of contaminated meal per 24-hour day.

2. A-H-W — Installation costs would be $1,000,000 to $1,300,000.

3. Two-stage aqueous acetone, anhydrous acetone (hexane) installation would cost about $1,300,000.

4. Installation costs for aqueous acetone extraction of contaminated cottonseed meal (100 tons per day) would be $500,000 to $700,000.

5. The installation costs of aqueous isopropanol extraction of contaminated cottonseed meal (100 tons per day) would be $500,000 to $700,000.

Operating costs per ton of cottonseed on a 212-ton seed basis for 250 operating days are as follows:

1. Ammoniation — $7 per ton of meal (less than $3.50 per ton of seed).

2. A-H-W — about $3 to $5 per ton of seed over conventional hexane-extraction operating cost.

3. Two-stage acetone — about $4 to $5 per ton of seed over conventional hexane-extraction cost.

4. Aqueous acetone — $12 per ton of meal, processed — seed basis, about $5.70 to $6 per ton.

5. Aqueous isopropanol — $13 per ton of meal processed — seed basis $6 to $7 per ton.

For the last two solvent processes using contaminated meal:

1. All costs must be charged to meal.

2. More steam will be required than for conventional hexane extraction.

3. More solvent is lost, and these solvents cost more than hexane.

4. The meals are more difficult to desolventize.

Summary. — Ammoniation appears to be the cheapest process investigated for the destruction of aflatoxin in contaminated cottonseed meal. It appears feasible for use, especially if the treated meal will be used for ruminant feeding only.

Aqueous isopropanol extraction of contaminated cottonseed meal also offers some real promise. First, the oil product is not involved — stability of the industry is from this standpoint not affected. Second, isopropanol is approved for use in fish-protein concentrates by FDA. Third, it would probably be easier to get overall approval by FDA. Fourth, meal quality, from the nutritional standpoint, is not appreciably affected. Fifth, overall process of hexane extraction, followed by isopropanol, can be changed to make further improvement in nutritional quality of meal for feed uses. Some conventional extraction equipment with modifications can be used.

We hope that as we get more information from the feeding tests underway and experience with these processes, we can make more conclusive recommendations as to the best process for industrial adoption.

AFLATOXIN AND OILSEEDS

by
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You are all familiar with the Turkey X disease encountered in Great Britain in the early sixties, and the subsequent investigations which showed that this mysterious disease was caused by a mycotoxin produced by Aspergillus flavus, which had earlier contaminated peanut meal coming from Brazil. These investigations showed that ducklings and chickens were also susceptible to the acute toxicity of aflatoxin, and that aflatoxin was a carcinogen for some species. It was also shown that a toxic metabolite was present in the milk of lactating animals when they were fed rations contaminated with aflatoxins. This toxic metabolite is now known to

be closely related to aflatoxin B_1 and is called aflatoxin M_1. Early investigations showed that M_1 produced bile-duct proliferation in ducklings, similar to the acute toxicity symptoms produced by the ingestion of aflatoxin B_1. Recent investigations with pure M_1 have shown it to be a carcinogen when fed to rainbow trout (10).

The initial aflatoxin problem was with peanuts and peanut products, but one of the next commodities to become involved was cottonseed meal. British veterinarians were investigating the cause of the reduction of milk production and the lack of consumption of feed by a dairy farmer's cows and found the cause to be aflatoxin-contaminated cottonseed (4).

Laboratory investigations showed that aflatoxin could be produced on any foodstuff which had been inoculated with an aflatoxin-producing strain of Aspergillus flavus. This, of course, merely showed that aflatoxin contamination was possible, but gave no indication of the probability that the food or feedstuff would be contaminated under use conditions. Surveys were conducted by FDA, USDA, and others to investigate the contamination in various commodities. These surveys revealed contamination in peanuts, Brazil nuts, cottonseed, corn, milo, copra, rice, walnuts, almonds, pecans, wine, and beer. This list is by no means complete, but serves to indicate that natural contamination of foodstuffs is quite widespread. When the information on the incidence of contamination of commodities indicated a potential problem, programs to control the situation were developed by cooperating efforts between the U.S. Department of Agriculture, State departments of agriculture, industry groups, and FDA. Specifically, programs for peanuts, Brazil nuts, copra, and most recently cottonseed have been developed and are periodically being reviewed and revised as necessary.

In the very early stages of this problem, we learned from the British that aflatoxin-free, refined vegetable oils could be produced from highly contaminated oilseeds. These findings were confirmed by experiments conducted by Parker and Melnick of Corn Products Company, International (5), using contaminated peanuts and corn germ. These experiments showed that most of the contamination remained in the oilseed meal, with some aflatoxin carrying through into the crude vegetable oil. Most of this aflatoxin was removed from the oil in the alkali-refining step, and the remaining traces of aflatoxin were removed in the subsequent refining steps.

At first, it was thought that the alkali-refining step destroyed the aflatoxin, but laboratory investigations showed that the lactone ring in the aflatoxins was opened by the alkali treatment to produce a nonfluorescent derivative of the aflatoxins. This reaction was reversed by the addition of acid to produce neutral conditions. Figure 1 shows the chemical reactions with aflatoxins which are involed with oil refining.

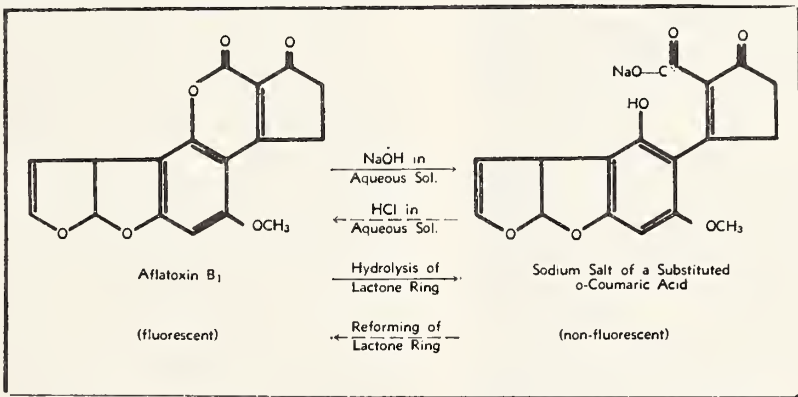

Figure 1. Chemical reactions of Aflatoxin B_1 associated with the refining of vegetable oils

Mrs. Cucullu and coworkers of the Southern Regional Research Laboratory here recently developed an analytical method for aflatoxin in soapstock which considers these reactions (2). These experiments on the processing and refining of vegetable oil clearly demonstrate that properly refined vegetable oil presents no problem to the consuming public, because the aflatoxin in the oilseed is completely removed in refining. Consequently, we have not focused attention on the refined oil and have permitted the use of aflatoxin-contaminated oilseeds for the production of oil. The oilseed meal and other byproducts are a concern when contaminated oilseeds are processed.

Figure 2 shows a reaction of some aflatoxins with water, a reaction which most likely is involved to some extent in oilseed processing. This compound has been called B_{2a}, the water adduct and the hemiacetal of B_1. This com-

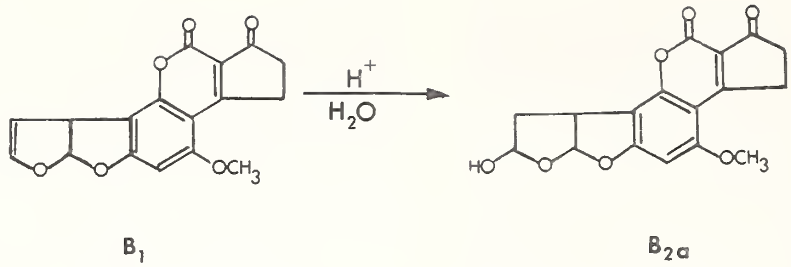

Figure 2. The formation of Aflatoxin B_{2a} from Aflatoxin B_1

pound has not displayed the acute toxic symptoms of the parent aflatoxin in ducklings, zebra fish, trout, and chick embryos. The chronic toxicity is currently under investigation; preliminary findings indicate that toxicity is not altered from that of the parent compound. Presently, there is no method for the detection of this reaction compound of aflatoxin. This is the principal reason that we do not know to what extent this compound is involved with vegetable oil refining. The compound is highly fluorescent and behaves on a thin-layer chromatography plate in a manner similar to that of aflatoxin M_1. Consequently, this compound can be easily confused with M_1 in TLC analyses, but would be disregarded in the usual aflatoxin analyses for aflatoxins B_1, B_2, G_1, and G_2. We are currently working on the development of analytical methods for this compound.

A number of studies have been carried out to establish aflatoxin levels which do not show harmful effects to meat animals. In many of the studies, the question of transmission of aflatoxins to tissues was not considered; in others, aflatoxins were not detected with the methods employed.

It has been well documented in the literature that the ingestion of aflatoxin by lactating animals results in the deposition of aflatoxin "M" in the milk. This is not merely a laboratory finding, because aflatoxin M has been found in samples of market milk in South Africa (6). Aflatoxin M has also been found in human milk and urine[1] (1, 7) and in other tissues of laboratory animals. A number of experiments have been conducted to investigate the deposition of aflatoxins or toxic metabolites in edible tissues of animals. These earlier literature reports have not revealed aflatoxins and toxic metabolites in edible tissues other than milk.

Recent studies, however, are now showing aflatoxins in edible tissues. At the factfinding conference of the Institute of American Poultry, held in Kansas City, Mo., in February 1970, Van Zytveld presented the findings of an investigation that he conducted at Kansas State University on the feeding of aflatoxin-contaminated rations to broilers. He reported the finding of aflatoxin and its metabolites in the skeletal muscles and livers of chickens fed aflatoxin. This work was also presented at the Poultry Science Association Meeting in August 1970 and was published in the September 1970 issue of Poultry Science (11).

Dr. Krogh and co-workers carried out a practical pig-feeding experiment at the Royal Veterinary and Agricultural University at Copenhagen, Denmark. In this investigation, they found levels up to 160μg. of aflatoxin per kilogram in liver, and smaller amounts in other edible tissues following consumption of aflatoxin-contaminated feed. Late in 1970, a summary of the study was published as a research report in Denmark (3), and a manuscript has been submitted for publication[2].

We collaborated with Dr. Krogh by carrying out some of the chemical and toxicological confirmation tests for this study, so we are familiar with many of the details. Three of the most significant facts coming out of this study are: (1) The large amounts of aflatoxin deposited in tissues, particularly the livers; (2) the individual animal differences, that is, some animals on a particular ration deposited aflatoxin in their tissues, whereas no aflatoxin was found in tissues of other animals on the same ration; (3) there were no gross lesions indicating harm to the animals. Most of the livers would have been passed by the meat inspectors; a few livers would have been condemned, but not the carcasses from which they were removed.

Dr. Armbrecht of the FDA Bureau of Veterinary Medicine found low levels of transmission of aflatoxin to livers, hams, and other tissues of hogs fed aflatoxin. This work was reported at a toxicology meeting in January

[1]Parpia, H. A. B. Private Communication. July 1967.
[2]Krogh, P. "Aflatoxin Residues in Swine Carcass," XIX World Veterinary Congress, Mexico City, Mexico, August 15 to 22, 1971.

1969 held at Williamsburg, Va.[3] Sims and others reported work carried out at Kansas State University on the feeding of aflatoxin to laying hens (8). They found a statistically significant decrease in egg production but did not find aflatoxins in the eggs or livers of the hens. However, they report that Wiseman, Bureau of Veterinary Medicine, FDA, found aflatoxins in eggs when hens were fed aflatoxin-contaminated feed containing 400μg. aflatoxin per kilogram of feed.

These recent studies clearly show that aflatoxins can be deposited in the edible tissues of animals consuming them. Dr. Goldblatt referred to the trout hepatoma episode in his presentation earlier this morning. This problem was encountered before the Turkey X disease, and before anyone was aware of the aflatoxins. However, it is now recognized that this problem was a result of aflatoxin contamination of the trout feed. We now recognize that the trout hepatoma problem was actually a combination of factors which present the most sensitive test system that we know of today for aflatoxins. These are the combination of the rainbow trout, the aflatoxins, and cyclopropene, fatty acids. The rainbow trout is the most sensitive test animal for aflatoxins known at this time, and the cyclopropene, fatty acids have been shown to be co-carcinogens for aflatoxins fed to trout (9). Thus we find that the presence of cyclopropene fatty acids in the aflatoxin-contaminated cottonseed meal being fed to rainbow trout presented the most sensitive aflatoxin-toxicity situation that has yet been encountered.

There have been several references so far in this meeting to plant-breeding programs for the improvement of cotton. You are all aware of the dramatic accomplishment of breeding rape seed which contains no erucic acid, and the high-oleic safflower oil that Dr. Senti described in his presentation yesterday afternoon. These are excellent examples of the use of genetics to tailor a product for a desired end, and they clearly indicate the effect of genetics on the fatty-acid composition of triglycerides. I would like to see the elimination of cyclopropene, fatty acids from cottonseed as one of the goals of a plant-breeding program. The elimination of the cyclopropene, fatty acid should result in a big improvement for the overall use of cotton, by eliminating one of its currently undesirable, inherent characteristics.

There is no tolerance for aflatoxin in any food, including feedstuffs. The toxicologists advise us that the scientific evidence does not permit the establishment of a safe tolerance. FDA has, however, established guidelines for regulatory actions. Initially, FDA announced that aflatoxin methodology permitted the routine confirmation of toxicity when chemical assays reported 30μg. of aflatoxin per kilogram of raw or finished products. About 2 years ago it was shown that improvements in the bioassay technique, and greater experience with the chemical and bioassay procedures, permit the routine confirmation of toxicity when the chemical procedures report 20μg. per kilogram. Early in 1969, FDA advised all concerned, including industry, USDA, and governments of other countries, that this lower guideline would be used in routine, regulatory actions.

There is some misunderstanding about FDA guidelines and FDA tolerances. They do not have the same meaning, nor are they used for the same purposes. Tolerances are established through procedures that require a showing of safety and a need for use. When FDA establishes a tolerance, theoretically at any rate, it is applicable to all lots of the food for which it is established, and safe to consume at that level. In practice, we do not expect the levels to consistently reach the tolerance on all lots, and this is borne out by experience.

Guidelines, on the other hand, are set where there are no tolerances, and where there is a need for general limiting values in the absence of specific information concerning the source of cause of the contamination. We do not expect all lots of food to reach the guideline level, either, and our experience is the same as with tolerances. Guidelines, and tolerances for that matter, are subject to change as new facts become available.

It should be emphasized that where there is specific information on the contamination, the guideline, whether for aflatoxins, pesticides, or other contaminants, is not controlling or applicable. In such cases, FDA reaches decisions based on the facts and circumstances of the specific incident. In other words, guidelines are not applicable where the processor fails to follow good manufacturing practices. In such cases, justifications for compliance action for levels lower than the guideline are sound. Almost never does a situation arise that requires a compromise to a level higher than the guideline.

Our action in reducing one guideline from 30 parts per billion to 20 parts per billion reflects our considered opinion that aflatoxins are hazardous to humans and to food-producing animals. It reflects our determination to keep foods that contain aflatoxins, irrespective of the

[3] Armbrecht, B. H. "Swine Aflatoxicosis". Presented at the Society of Toxicology, Williamsburg, Va., January 1969.

cause, out of food channels insofar as possible. It is likely that these policies and guidelines will undergo changes in the future, as they have in the past. Additional research in toxicology, analytical methodology, agricultural practices, and processing techniques will dictate changes. What the changes will be, and when they will come, depend on many factors which cannot be predicted today.

In conclusion, three specific areas of cooperative efforts have been taken to assist in bringing the current cottonseed problem under control. I mentioned earlier that specific programs are developed when we have information indicating a potential problem in specific commodities. Samples of cottonseed meal have been analyzed by FDA over the years, and the results did not indicate a problem. Published surveys conducted by the cooperative efforts by the USDA and industry also indicated that we would not expect a general problem with cottonseed in the United States. However, there were indications that the samples found to be contaminated with aflatoxin were pretty much confined to a specific geographical area. The situation changed last spring, when samples of cottonseed and cottonseed meals showed relative high levels of aflatoxin contamination.

A joint meeting was arranged and held in August between industry, USDA, and FDA to discuss the situation. The various aspects of the problem were discussed, so that all of the available facts and information could be brought to bear in taking corrective actions. An aflatoxin analytical workshop was held at the FDA's Los Angeles District Laboratory the last day of October. This workshop was arranged after discussions with California State officials and industry representatives indicated that a workshop confined to the methodology for cottonseed, copra, and their respective meals should be helpful in developing skills in these analyses, so that a better correlation of results could be attained. About 20 laboratories were represented at this 2-day workshop. Plans have been developed for a 1-day workshop during the latter part of March 1971 at Phoenix, Ariz., for cotton growers and ginners, with emphasis being placed on possible means to control the problem.

The foregoing are specific steps that have been and are being taken on cottonseed. Past experience has shown that a cooperative effort between industry and government agencies has been effective in bringing the problems with other commodities under control. We are convinced that this approach will help minimize the cottonseed problem and that FDA will continue to assist in cooperative efforts such as these in the future.

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AFLATOXIN PROBLEM — THE USDA POSITION

by

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This statement relates mainly to the USDA position on aflatoxin, as viewed from its marketing activities. It necessarily recognizes that additional knowledge is needed from research to modify and improve present positions and actions on the aflatoxin problem by the U. S. Department of Agriculture (USDA), the Food and Drug Administration (FDA), and industry.

Of interest on marketing are the Commodity Credit Corporation's (CCC) price support programs, marketing agreement programs, and the inspection services for fresh and processed commodities.

The first decision to use Department of Agriculture marketing programs to help cope with the aflatoxin problem was made in 1964. At that time, peanut industry spokesmen said that they would be unable to obtain funds with which to finance normal purchases from the crop unless something could be done to protect them against the hazard and risk of loss posed by aflatoxin. First, a public scare, even though

wholly unjustified, could have caused a great reduction in the consumption of peanut products. This could have left handlers, who had made normal purchases directly from producers at harvest time, with large, unsaleable inventories. Secondly, an indeterminate number of lots of peanuts, after milling, might be unsuitable for food use because of aflatoxin.

Price support for peanuts is mandatory. The support level, which is related to the value of peanuts for food use, is more than twice the value of peanuts for crushing into oil and meal. If shellers could not finance normal purchases, the Department would acquire most of the crop, rather than the surplus portion above food needs. Thus, program costs would be much larger. The Department was deeply concerned about the possible adverse effect upon peanut producers. Furthermore, the Department shares responsibility for protection of the quality of agricultural commodities and food products in the public interest.

The Department's policy generally is to deny support for any lot of a commodity which is unsuitable for its normal market uses. Price supports are not used for regulatory purposes. The decisions regarding aflatoxin since 1964 do not change this basic policy. Rather, they permit action designed to protect and reconcile interests of the Department, producers, industry, FDA, and the public.

For the 1964 crop, actions on quality regulation and indemnification were handled under contracts between CCC and individual peanut shellers, but with the statement that these activities would be shifted to a marketing agreement for the 1965 crop.

The marketing agreement is administered by a committee of producers and shellers. However, the terms and conditions of the agreement are developed with the understanding and support of manufacturers of peanut products.

Action now taken under the marketing agreement provides: (1) For inspection of all peanuts when delivered by producers, with removal from food trade channels of lower quality lots, including those on which A. Flavus mold is visible under a low-power microscope; (2) sampling by Government inspectors and testing for aflatoxin of all lots of raw, shelled peanuts — USDA, Consumer and Marketing Service (C&MS) laboratories are used on tests of all disputed lots; (3) diversion from food channels of all lots of raw, shelled peanuts with aflatoxin above a specified level; and (4) indemnification for shellers on lots diverted to crushing because of aflatoxin.

Manufacturers have developed a voluntary code of good manufacturing practices. Peanut meal with aflatoxin above FDA established "working" or "guideline" levels is sold for fertilizer within the United States, or for export with the aflatoxin level marked. The value of this meal is less than its value for feed.

The entire USDA "action" program for aflatoxin has been built upon the foundation of the knowledge provided by the excellent group of scientists in Agricultural Research Service. Without the knowledge and assistance that these scientists give, those engaged in marketing would not know how to proceed.

The second commodity with a serious problem regarding aflatoxin is cottonseed. In some ways, the problem with cottonseed is not as serious as that on peanuts. First, the meal fraction which carries the aflatoxin goes into feed rather than food. Thus, there is less likelihood of a public scare than over peanuts — particularly peanut butter — as a food. Second, animals consuming the meal may pass aflatoxin through their systems without retention in the meat, or milk, or eggs. However, this is an area of uncertainty on which extensive research is underway. Third, aflatoxin contamination of cottonseed is not as widespread a problem geographically as it is in peanuts. Fourth, "inactivation" of aflatoxin in meal may prove to be practical, whereas removal of individual kernels is necessary for peanuts in food.

In other ways, the aflatoxin problem is more serious for cottonseed than for peanuts. First, it is impractical to remove contaminated seed. Contaminated peanut kernels, however, can be removed. Secondly, the identification and separate processing of contaminated and uncontaminated lots of cottonseed is exceedingly difficult. Third, contamination in certain limited areas may be so high at times that processing the seed is no longer economically feasible. Fourth, on the aflatoxin problem, USDA assistance through its price support and marketing activities may be of little or no aid to producers and processors. This was true of the support programs for the 1969 and 1970 crops.

Under the program, participating oil mills are obligated to pay not less than support for seed. If, at any time during the marketing year they cannot sell products (oil, meal, hulls, and linters) for an amount equivalent to support, plus a reasonable operating margin, then CCC is obligated to buy oil (and, under some conditions, meal) at prices high enough to enable the mills to recover that amount. Aflatoxin-contaminated meal can be tendered to CCC at anytime. However, with support at $37 per ton, farm level, and favorable market prices for oil, the CCC commitment currently requires payment of only about $20 to $25 per ton for the meal. Mills can sell the meal for export or for

fertilizer use at better prices. The Department has announced that it does not plan to offer price support for the 1971 cottonseed crop.

Possibly, USDA inspection and testing and a marketing agreement could be helpful. Application and operation would be difficult and limited in scope, but it might be useful to the industry in its efforts to comply voluntarily with FDA requirements.

USDA is making extensive efforts to find new knowledge and better ways of handling aflatoxin and other mycotoxin problems. On cottonseed, peanut, and copra meals, and possibly on grains, the present situation with aflatoxin is unsatisfactory. Action such as that for peanuts for food use is impractical.

Research has not yet yielded means of preventing mold and aflatoxin. It has provided methods of "removing" or "inactivating" aflatoxin in meal. However, FDA insists upon lengthy feeding tests before approving use of the meal.

USDA feeding tests with aflatoxin-contaminated meal indicate that aflatoxin at problable actual levels, as part of the feed ration, is not harmful to ruminant animals or swine. Good results have been reported from commercial feeding of whole cottonseed as part of dairy rations in the California area. There apparently is some unidentified "beneficial" factor such as the "unidentified growth factor" in fish meal.

USDA tests indicate either that aflatoxin residue is not left in the meat or that it is very small. The contrary position of FDA on residue in meat may be unnecessarily rigid. The "zero" level for aflatoxin under existing law for feeds may be unnecessary in order to protect the public health. If further developments so indicate, then modification of the present FDA guidelines or a change in existing law may become appropriate.

By way of summary, as the situation looks from the marketing side of USDA activities, these observations seem to be in order.

1. Department price support and marketing agreement programs can be used for some commodities to strengthen an industry-wide effort to cope with the aflatoxin problem. This is demonstrated by the activities on peanuts. The programs may be of only limited aid on other commodities. This is demonstrated by cottonseed.

2. Existing knowledge does not provide definite answers on the basis of which action can be taken to remove the aflatoxin-contaminated portion of some commodities (cottonseed, for example) or to inactivate — with FDA acceptance — the aflatoxin in the commodity or products produced therefrom.

3. In the light of existing knowledge, there is some basis for questions as to whether FDA enforcement action in relation to aflatoxin contaminated feeds — before or after "inactivation" — is unnecessarily strict. The question may be resolved by research already underway. The need for this research is urgent.

4. USDA in its marketing activities and in the continued search by its scientists for needed additional knowledge will make every effort to contribute constructively to the handling of the aflatoxin problem.

GOOD MANUFACTURING PRACTICES — GMP IMPACT UPON INDUSTRY

by
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It would be a difficult assignment for anyone to stand before you today and accurately predict the impact that the Federal Food and Drug "Good Manufacturing Practices" will have on the Oil Mill Industry. It seems reasonable to the writer to believe that this impact may vary from oil mill to oil mill, depending entirely upon the seriousness with which an oil mill has attempted in the past to comply with the spirit of the Federal Laws under which the Food and Drug Administration (FDA) operates. An oil mill, should there be one, that has operated on the basis of doing only that which is necessary to "just get by," may find a very definite impact on its operation as a result of the Good Manufacturing Practice regulations. On the other hand, an oil mill that has an established, good sanitation program as an integral part of its operation, takes pride in producing wholesome quality products, and has made an honest effort to operate within the spirit of the law, may feel very little impact from the Good Manufacturing Practice regulations.

Many of us who have been associated with the oil mill industry for a sufficient length of time have seen a different climate develop over the years in the relationship between industry and FDA. Many years ago, the oil mill industry was hardly affected by FDA. As FDA's budget was increased along with the number of its

personnel, a number of industries, including our own, felt the effects. FDA undertook a campaign to "clean up" industries that for too long, we must all agree, had been lax in mill sanitation. They had a job to do that needed to be done, and used the only tool available to them, the Federal Food, Drug, and Cosmetic Act. Oil mills were cited, hearings were held, court actions were taken, and penalties were applied to accomplish the objective. The oil mill industry, along with some others, began to look upon FDA as a police force.

Over the years, however, as our industry became more aware of what was expected of it, we have seen evolve in FDA a spirit of promoting voluntary compliance, where possible, which has been a very healthy development for our industry. It is the writer's sincere belief that, with very few exceptions, oil mills today take pride in their plants, in their operation, and, yes, in producing a pure and wholesome product. There still exists the law, however, for the few exceptions that have not yet become "believers."

The writer believes that one of the results of the evolvement of a spirit of promoting voluntary compliance by FDA has been the development of the regulations known as Good Manufacturing Practices, which were published in Volume 34, No. 80, of the Federal Register on April 26, 1969. Voluntary compliance now will make more sense than ever, since reducing these regulations to print should enable industry now, more than ever, to know what is expected of it. Before it could only be guided by the law and its exposure to FDA inspectors. So, this is a healthy development. Admittedly, at least in the writer's judgment, there is room in GMP for difficulty to industry should an oil mill become involved with a "nit picking" inspector. However, it has been the writer's experience with FDA through the years that it exhibits a spirit of reasonableness to our industry.

Our industry must realize, and the writer feels sure that FDA realizes it, is that the Good Manufacturing Practice regulations are applicable to all industries that manufacture, process, pack, or hold human foods. Because of this, of necessity the GMP regulations are somewhat general, and it would seem reasonable to assume that because portions of the regulations may have more meaning in one industry than in another. In this connection, FDA is encouraging each industry to cooperate with it in developing more specific regulations for its particular needs.

For example, there already exists an official set of regulations for the breaded-shrimp industry. This does not mean that the breaded-shrimp industry can forget about the general GMP regulations. The breaded-shrimp industry is still subject to the general GMP regulations as an "umbrella," but with the publishing of more specific regulations for its own particular industry, it has a better understanding of what is expected of it.

Our industry has a committee now at work in cooperation with FDA, attempting to develop a set of guidelines or regulations for the oil mill industry. These are to be much more specific in their content than the general GMP regulations. When these guidelines have been developed, however, our industry will still be subject to the general GMP regulations as an "umbrella."

At this point, we may mention some of the provisions of the Good Manufacturing Practice regulations so that you can determine for yourself the potential impact that these provisions may have upon your own oil mill. First, however, each of you involved in the operation of an oil mill should have a copy of the GMP. If you do not have one, you should get one. It is officially referred to as "Part 128-Human Foods; Current Good Manufacturing Practice (Sanitation) In Manufacture, Processing, Packing, or Holding." As previously mentioned, it was published in the Federal Register, Vol. 34, No. 80, on Saturday, April 26, 1969. It is significant to note that these regulations have been official now for almost 2 years.

Now to mention some of the provisions of GMP:

PLANT AND GROUNDS

The grounds about a food plant under the control of the operator are to be free from conditions which may result in the contamination of food, including, but not limited to:

1. Improperly stored equipment, litter, waste, refuse, and uncut weeds within the immediate vicinity of the plant building.
2. Excessively dusty roads, yards, or parking lots.
3. Inadequately drained areas.

Plant buildings and structures are to be suitable in size, construction, and design to facilitate maintenance and sanitary operations, and shall:

1. Provide sufficient space for placement of equipment and storage for materials. Floors, walls, and ceilings are to be of cleanable construction and shall be kept clean and in good repair. Fixtures, ducts, and pipes shall not be so suspended over working areas that drip or condensate may contaminate foods, raw materials, or food contact surfaces.
2. Provide separation by partition, location, or other effective means for those operations which may cause contamination of food products.
3. Provide adequate lighting to hand-washing areas, dressing and locker rooms, and

toilet rooms, and to all areas where food or food ingredients are examined, processed, or stored, and where equipment and utensils are cleaned. Light bulbs, fixtures, skylights, or other glass suspended over exposed food in any step of preparation shall be of the safety type or otherwise protected to prevent food contamination.

4. Provide adequate ventilation or control equipment to minimize odors and noxious fumes, including steam, in the areas where they may contaminate food.

5. Provide, where necessary, effective screening or other protection against birds, animals, and vermin.

SANITARY FACILITIES AND CONTROLS

Each plant will be equipped with adequate sanitary facilities and accommodations including, but not limited to:

1. An adequate and pure water supply.
2. Adequate sewage disposal facilities.
3. Adequate plumbing as to size and design.
4. Proper toilet facilities, including handwashing facilities.
5. Doors to toilet rooms are to be self-closing and shall not open directly into areas where food is exposed to airborne contamination unless precautions have been taken such as double doors, positive airflow systems, etc. Signs are to be posted directing employees to wash their hands with cleaning soap or detergents after using toilet.
6. Adequate hand washing facilities with running water at a suitable temperature for washing hands, with proper sanitary towels and appropriate waste receptacles.
7. Rubbish and offal is to be disposed of so as to minimize the development of odor or from becoming an attractant and harborage, or breeding place for vermin.

SANITARY OPERATIONS

a. Buildings and other physical facilities are to be kept in good repair and maintained in a sanitary condition. Only those toxic materials necessary to maintain sanitary conditions, for use in laboratory testing procedures, for plant and equipment maintenance and operation, or in manufacturing or processing operations are to be stored in the plant.

b. No animals or birds are to be allowed in any area of the plant. Effective measures are to be taken to exclude pests from the processing areas.

c. All utensils and product contact surfaces of equipment are to be cleaned as frequently as necessary to prevent contamination of food and food products. Nonproduce contact surfaces are to be cleaned as frequently as is necessary to minimize accumulation of dust, dirt, food particles, and other debris.

d. Cleaned and sanitized portable equipment with product contact surfaces are to be stored in such a location and manner that these product contact surfaces are protected from splashes, dust, and other possible contamination.

PROCESSES AND CONTROLS

All operations in the receiving, inspecting, transporting, packaging, segregating, preparing, processing, and storing of food are to be conducted in accord with adequate sanitation principles. The overall sanitation of the plant is to be under the supervision of an individual who is assigned the responsibility for this function:

a. Raw material and ingredients are to be inspected and segregated, if necessary, to assure that they are clean, wholesome, and fit for processing into human food, and shall be stored under conditions that will protect against contamination and minimize deterioration.

b. Containers and carriers of raw materials should be inspected upon receipt to insure that their condition does not contribute to the contamination of the product.

c. When ice is used in contact with the food products, it should be made from potable water, and produced, stored, transported, and handled in a sanitary manner.

d. Food-processing areas and equipment used for processing human food are not to be used for processing nonhuman food-grade animal feed, or inedible products, unless there is no reasonable possibility of contamination of human food.

e. Processing equipment shall be maintained in a sanitary condition through frequent cleaning.

f. All food processing, including packaging and storage, should be conducted under such conditions and controls as are necessary to minimize the potential for undesirable bacterial or other microbiological growth, toxin formation, or deterioration or contamination of the processed product or ingredients.

g. Chemical, microbiological, or extraneous material-testing procedures are to be used where necessary to identify sanitation failures or food contamination.

h. Packaging processes and material shall not transmit contaminants or objectionable substances to the product.

i. Meaningful coding of products sold or otherwise distributed from a manufacturing, processing, packing, or repacking activity should be used to enable positive lot identification to facilitate, where necessary, the segregation of

specific food lots that may become contaminated.

j. Storage and transportation of finished products should be under such conditions that will prevent contamination.

PERSONNEL

Plant management is to take all reasonable measures and precautions to assure the following:

a. No person affected by disease in a communicable form, or while a carrier of such disease, or while affected with boils, sores, infected wounds, or other sources of microbiological contamination shall work in a food plant in any capacity in which there is a reasonable possibility of food or food ingredients becoming contaminated.

b. All persons, while working in direct contact with food preparation, food ingredients, or surfaces coming into contact with food shall:

1. Wear clean outer garments and maintain a high degree of personal cleanliness.

2. Wash their hands thoroughly before starting work or after each absence from the work station.

3. Remove all insecure jewelry during periods which food is manipulated by hand; remove any jewelry worn on the hands.

4. If gloves are used, they are to be maintained in an intact, clean, and sanitary condition.

5. Wear hairnets, headbands, caps, or other effective hair restraints.

6. Not store clothing or other personal belongings, eat food or drink beverages, or use tobacco in any form in areas where food or food ingredients are exposed.

7. Take any other necessary precautions to prevent contamination of foods including, but not limited to, perspiration, hair, cosmetics, tobacco, chemicals, and medicants.

8. Personnel responsible for identifying sanitation failures or food contamination are to have a background of education, or experience, or a combination thereof, to provide the proper level of competence.

9. Responsibility for assuring compliance by all personnel with all requirements is to be clearly assigned to competent supervisory personnel.

The above outline of GMP should give you an idea of the content. However, to avoid any misunderstanding, every person having any responsibility for the level of sanitation at an oil mill should read for himself the Good Manufacturing Practice regulations in their entirety.

The writer has attempted to give a fairly complete outline of all the provisions included in the Good Manufacturing Practices. As a result, you can visualize that some of the provisions are included for those industries more closely identified with end products shipped to the consuming public than is the oil mill industry. As has been mentioned previously, one would assume that some of the provisions would, as a practical matter, receive much less emphasis by an inspector dealing with an oil mill than would others. For instance, keeping one's plant free of animals, birds, insects, etc., in an oil mill would seem to carry a much greater priority than would wearing hair nets, removing jewelry, etc. The writer, however, has purposely attempted to include a brief summary of all the provisions in order to avoid misleading anyone, as well as to point out the importance of our industry developing, in cooperation with FDA, its own guidelines for Good Manufacturing Practices.

Although your writer may not have dealt adequately with the subject of this paper to the point of accurately predicting the impact that these Good Manufacturing Practices may have on our industry, if he has properly presented to you the intent and spirit of these Good Manufacturing Practices to enable you to evaluate the impact on your own oil mill, then his objective will have been accomplished.

IMMEDIATE POLLUTION PROBLEMS ASSOCIATED WITH THE PROCESSING OF OILSEEDS

by
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Pollution control regulations are now an important factor for the management of oil mills to consider even though most Southern States and individual communities had practically no restrictions in this area as recently as 3 years ago. Of course, there have been some States, such as Tennessee, which have had stream pollution control regulations for more than 25 years, and Arkansas, which passed its first pollution control law in 1949, but few oil mills were ever involved with the agencies handling those programs. Only during the most recent times has there been any emphasis at all on air pollution control.

Now the situation has changed. The need for pollution control is receiving tremendous publi-

city, and public support is mounting. Although this intense interest may diminish, there can be no doubt that the regulations and laws which it generates will remain with us. Consequently, all industries are going to have to accept the fact that pollution control measures are here to stay as a cost of doing business.

My purpose today is to discuss the present regulations and the potential future ones which will effect oil mills in the Mississippi Valley. I feel quite certain that most mills will have trouble with air pollution regulations to a greater degree than those affecting waste water. Consequently, I intend to delve into the air pollution control regulations much more thoroughly than those on water pollution, but I want to touch upon the water measures first.

Many cities and towns in the South do not now have sewage treatment facilities, or if they do, they are inadequate. This means that we are going to see a lot of activity in this area in the next few years. Since most oil mills are located in such towns or cities, they are going to feel a direct effect from this. Although the oil mills themselves may not be required to install treatment facilities, the cost of building and operating the municipal facilities is going to be passed along to them when it is applied to all industries which send waste water to a municipal sewage treatment plant.

There are two possibilities. One is that oil mills, along with all other industries, will be required to pay sewage fees on both the volume of waste water and the content (usually measured in p.p.m. of biochemical oxygen demand and suspended solids). The other is the possibility that smaller towns, or even larger cities with inadequate treatment plants, will find it necessary to limit the biological oxygen demand (BOD) and suspended solids levels of sewage which can be dumped into the city sewage system.

Memphis is an example of a city which has just recently adopted this sewage fee ordinance under the former approach. There is no restriction on the amount of BOD and suspended solids which may be placed in the sewer, as long as the industries involved pay the required fee. However, this is prohibitive in some cases. Oil mills which have waste oil or meal in their sewage will find their BOD levels quite high. BOD concentrations in levels above 2,000 p.p.m. are not uncommon. As a result, it may be possible to justify centrifuging of waste water with the savings not only from the sewer fee, but also from the recovery of oil and meal.

The second possibility can also affect oil mills which do not have waste-oil separation equipment. Nashville is one of the cities which is currently considering a limitation on the BOD levels of waste water which can be dumped into the city sewer system. Again this is most likely to help the justification of centrifuges.

In either case, oil mills will have a little time before they are directly affected by these regulations. However, there are oil mills which are faced with an immediate waste-water problem. Those are the few mills which discharge directly into streams or lakes, regardless of whether they have their own treatment facilities. Under a new program, announced in late December 1970, the Federal Government will require reporting of such waste-water discharges. This is being done under an Executive Order from the President of the United States, and the details are to be handled by the U.S. Army Corps of Engineers. The report of discharges is to be used in a program of Federally controlled permits.

Legal justification for the requirement of the use of reports is the Refuse Section of the 1899 River and Harbor Act. It is not until just recently that the Act has been interpreted in this manner. However, the President is apparently on sound ground in his interpretation of it, and most industries are simply waiting to see what the procedure will be for handling reports and permits. If the reporting forms are as complicated as a voluntary one which was recently used by the Federal Water Quality Administration, many oil mills may find themselves in need of technical consultants to handle the details of the report.

Despite this flurry of activity in water pollution control, air pollution control laws and regulations are of a much more immediate concern to oil mills. Almost all mills are affected, and every State has begun some form of enforcement.

In the South, the most common form of air pollution is particulate matter. This means suspended solids or liquids discharged into the air. We see its visible effect in the griminess of masonry buildings, the shortened life of house paint, the mysterious death of vegetation, and in some areas, housewives notice its effect upon laundry. However, the area of greatest danger is not as readily apparent. This involves lung damage.

As particulate matter collects in the lungs, it contributes to the deterioration of internal cell walls. A normal teenager has a lung capacity four times that necessary to sustain life. As we get older and the cell walls in our lungs break down, lung capacity can be reduced to the point where we are able to absorb only enough oxygen to stay alive. This is one of the reasons that youngsters have a greater ability to participate in sports than older people. Damage to the lungs caused by particulate matters hastens this aging process.

In our area of the South, particulate matter is a relatively greater air pollution problem than

in other areas of the country, simply because we do not suffer from many of the other types of air pollution which are found in areas such as the east and west coast. For instance, automobile emissions of hydrocarbons, nitrous oxides, and other photochemical agents which can produce smog, do not present a great problem for us, because we do not have the same meteorological conditions found in those other areas of the country. The inversions which hold dangerous automobile emissions in the air over Los Angeles, Calif., rarely occur in the air over the Mississippi Valley.

Weather bureau data indicates that Memphis has an average of only one inversion of 4 days duration each year, whereas many coastal or mountainous communities may experience such inversions during more than one-third of the year. For this reason, the air pollution regulations in our area do not have to be as stringent as they are in other areas in order to provide our people with the same health protection.

Nevertheless, because oil mills are most apt to discharge particulate matter into the atmosphere, they are still going to be a prime target for whatever air pollution regulations are drawn by Southern States. Today, I am going to talk about the regulations in use in the States of Tennessee, Mississippi, and Arkansas.

Regulations in these States have been drawn on differing theories of air pollution control. Tennessee uses the dispersion theory. This means that if particles are discharged high enough into the air through tall smoke stacks or through transportation by hot gases, the pollutants will be widely dispersed and thinned out enough so that they will not be sufficiently concentrated to be harmful when they return to earth where they can be breathed by humans.

If there were enough wide open space, this might be a very sound theory. However, in areas of heavy population density, the cumulative effect of several neighboring industries discharging particulate matter into the atmosphere may totally offset any dispersion effects. In addition, regulations of this type discriminate against industries which have short stacks and low discharge temperatures. The oil mills would commonly fall into this category and tend to suffer by this type of regulation.

Mississippi, on the other hand, uses the process emission approach, which states that an industry may put only so many pounds of dust particles into the air, per hour, for so many pounds of product handled through the process, per hour. This approach limits the total amount of particulates which can be placed in the air from all sources, and is gaining favor with most pollution control experts. In addition, it is much fairer to smaller companies.

A third approach is most nearly a combination of the Tennessee and Mississippi regulations, and is being used by the State of Arkansas. There, air pollution control equipment is required to meet certain standards of efficiency in the removal of pollutants. In addition, the air which passes over a plant must not pick up concentrations of particulate matter above a certain level. This is measured by tests upwind and downwind from the plant. Since the purpose of all pollution control regulations is to limit contamination of the air, the Arkansas regulations may theoretically be the most effective in obtaining desired health benefits.

Now let's talk about the specifics in these regulations and how they are applied to oil mills. In Tennessee, the State Air Pollution Control Board exercises authority over only 91 of the 95 counties. The other four — Shelby, Knox, Davidson, and Hamilton — have been allowed to set up their own regulations, as long as they are more stringent than those of the State. Generally they are, and they are also much closer to the Arkansas and Mississippi emission regulations than they are to the Tennessee theory of control.

In the 91 counties, all industries were required to report on inventory of their air pollution emissions by August 9, 1970. Many industries failed to meet this deadline, and the State Air Pollution Control Division is currently making a survey to find those who failed to report. When submitted, these reports will be used to determine whether the individual industries are in compliance with the present State regulations. If not, they will be given until February 9, to either meet the requirements or to report the specific steps and dates which will be met to comply. In the four municipal counties, the schedule varies. Memphis requires all incinerators to be in compliance by May 1971, and all other pollution sources to meet the Memphis regulations by May 1972. However, there are few oil mills in Tennessee.

In Mississippi, the regulations have already gone into effect, and all industries within the State are supposed to have reported the existence of their air pollution outlets and pollution control equipment in order to obtain temporary permits. Under the Mississippi regulations, companies may continue to operate under a temporary permit on an almost indefinite basis, until the adequacy of their pollution control equipment has been determined. The State does not push for this determination, unless it receives some complaint. This means that oil mills located within cities, towns, or otherwise densely populated communities, may be forced to comply with the Mississippi regulations long before mills which are located away

from population centers.

There is also the possibility that the Mississippi Air and Water Pollution Commission may set a specific date for compliance by a specific industry. This has already happened in the case of cotton gins, which are required to stop burning trash in teepee burners by July 1, 1971, unless the burners can meet the Mississippi Air Pollution Control regulations, no matter where the cotton gins are located. Conceivably, the same thing could happen to oil mills in the case of dust emissions. However, the Mississippi-process emission regulations are lenient enough so that any oil mill which has good dust-collecting equipment and keeps it in good running order should be able to pass the requirements to move from a temporary permit to a "Permit to Operate."

Arkansas has also put its regulations into effect, and all industries in the State were supposed to have registered their air pollution control equipment and uncontrolled discharges of air contaminants no later than 90 days after July 30, 1969. New industries, or expansions of existing equipment, are supposed to secure a permit from the Arkansas Pollution Control Commission before construction is even started, if there is to be any discharge into the air. The Commission will review plans to determine compliance before granting the permit.

Existing industries were allowed to make a self-determination of compliance, and if they are not meeting regulations, they were expected to offer a schedule for compliance. Many have not done this, and the Pollution Control Commission is currently engaged in tracking down the firms which have not taken action. The risk for companies which have not voluntarily made some move in that direction is that the State may arbitrarily set a date for compliance which will require an expensive "crash" program to meet.

Compliance with State air and water regulations is going to mean an expenditure of capital funds for the purchase and installation of pollution control equipment. Most States have come to recognize the fact that this type of equipment does not produce a profit for the company which installs it and, consequently, deserves some special tax treatment. After all, it is being installed for the good of the general public, and in all probability, will be purely a cost item.

In response to this situation, most Southern States have granted some type of tax relief for pollution control equipment. Tennessee exempts all such equipment from property taxes under TCA 67-512. Louisiana grants a property tax exemption for 10 years from State and local property taxes under Article 10, Section 4, Paragraph 10 of the Louisiana Ten Year Tax Exemption Law. Albama gives a variety of credits. There, the equipment is exempt from property tax under Act 1137, sales taxes under Act 1139, use taxes under Act 1141, income taxes under Act 1136, and franchise taxes under Act 1138. Florida has a unique approach. Air and water pollution control equipment there is assessed at no more than the salvage value, and the replacement of old equipment with new does not increase tax valuation under Section 403.241. Georgia gives property tax exemption under Georgia Code Annotated, Section 92-201.1, and sales tax exemption under Georgia Code Annotated 92-3403aC.

North Carolina has one of the most generous arrangements. Corporations may claim State income tax decuctions for amortization of air and water pollution control equipment over a period of 60 months under Section 105-130.10. In addition, both land and equipment used primarily for air and water pollution control are exempt from real estate taxes under Sections 105-296 and 105-297. South Carolina gives a property tax exemption under Section 65-1522.51-A. However, there are States which have made no provisions for tax incentives. Among these are Texas and Mississippi. Arkansas has given no tax relief in the past, but there is a bill in the Arkansas Legislature this year which would allow for a 10-percent deduction against all taxes due the State. Finally, the Federal Government allows a fast, 5-year amortization of pollution control equipment. However, unless a company is making a profit, none of these tax benefits will be of any use.

Furthermore, before any decision can be made on proper pollution control equipment selections, the problem must be defined. Consequently, my final message is that it may be more economical to spend a little money now to determine where you stand than to wait until you are forced to do something under pressure, which may cost far more.

SESSION III: L. J. Melder, The Southern Cotton Oil Co., Inc., Natchitoches, La., Chairman

THE TECHNOLOGY OF COTTONSEED PROTEINS[1]

by

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(Presented by W. H. Martinez)

Technology is defined as the systematic treatment of an art. There are few, I believe, who would disagree with the statement that oilseed processing is an art. You, the oilseed processors, are the men knowledgable in this art, i.e., knowing how to handle this year's crop. For cottonseed, like other agricultrual commodities subject to the vicissitudes of nature, is never the same 2 years in succession. The state of the art and the systematic treatment of it have been the subject of these conferences for the past two decades. Men such as Cecil Wamble and Porter Williams — to whom this conference is dedicated — have extended and carried forward the systematic treatment of this art.

The technology of the past decades was, however, devoted primarily toward producing the best in quantity and quality of cottonseed oil, with as little reduction in protein quality of the meal as possible. It has been a technology predominantly concerned with cottonseed oil, gossypol inactivation, and nutritive quality of the meal, and it has, in large measure, been a success. Cottonseed oil continues to maintain its position relative to supply in the oil market, and cottonseed meal, in addition to the traditional ruminant market, is now used in nonruminant feeds.

Forecasts for the coming decade, however, suggest distinguishable changes in the relative importance of oil and protein, and new markets for the protein as food rather than feed (15). But as markets and products change, so must technology. Rather than gossypol inactivation and nutritive quality, the technologist must now address the problems of gossypol removal and functional quality. Changes in processing guidelines, which in many cases may be subtle, but very important, must be recognized and executed, and a new state of the art brought into existence.

An edible-protein market will be an annual market with little seasonal variation. Storage of sufficient seed or sufficient product to meet the market demands will be a necessity. Selection of seed, not only for absence of aflatoxin, but also for maturity, will be important to the function and yield of the protein product. The cottonseed, 26 to 30 days after flowering, is equal in length and weight to the mature seed, but physiologically it has just begun to assume its mature composition and structure. At 26 days, the embryo contains large vacuoles which have not yet attained the shape and content of the protein bodies of the mature seed (4, 17).

Therefore, at 26 days, the seed is deficient in one of the major protein components — the storage proteins. These are the proteins of major interest in our studies thus far. The initiation of germination, in the boll or under adverse storage conditions, will also result in a decreased yield of storage proteins due to enzymatic hydrolysis. Also, there is the problem of overheating during storage, which will not change the protein content, but could greatly affect the extractability and, consequently, the yield and composition of the edible-protein product. The seed, therefore, must be carefully selected for maturity and absence of filth and aflatoxin, and stored under conditions which will maintain quality.

The inherent extractability and functional characteristics of the cottonseed proteins also must be retained during the defatting operation. The type of seed being processed, glanded or glandless, will dictate the type of defatting operation used. Direct solvent extraction is appropriate for glandless cottonseed with two qualifications — the hull content of the meats and the method of desolventization. Hull removal is a quality control operation which affects the color, fiber, and microbial content of the flour. Hulls cannot be obliterated after defatting by merely reducing the particle size. Hull content, like bacterial count, is best controlled from the beginning of the process.

Proper desolventization — i.e., vapor phase or its equivalent, is important to the color, extractability, and functionality of the protein product. Sufficient moisture and temperature, even in the absence of free steam, can result in browning and reduced extractability.

With glanded cottonseed, the liquid-cyclone

[1]This work has been supported in part by the National Cottonseed Products Association, the Foundation for Cotton Research and Education, and Cotton Incorporated.

process (14) is the method of choice. Only by removal of the intact pigment gland can the color of the glanded protein product approach that of the glandless material. The seed constituents of glanded and glandless cottonseed, other than gossypol, have been found to be the same (13), and the problems will be the same. However, the liquid-cyclone process, which uses low-moisture meats, potentially has less of a desolventization problem. In addition, the centrifugation operation used to remove pigment glands also provides finite control of the hull content.

Either product must meet the microbiological standards required of food-grade materials and must be packaged and stored in a manner which will maintain the food-grade quality (16).

The composition of the liquid-cyclone flour (14) and of the glandless flour prepared on a semicommercial scale at Oklahoma City, Okla., is given in table 1. Both more than meet the guidelines for edible cottonseed flour set forth by the Protein Advisory Group of the United Nations. However, nutritive, not functional quality, was the dominating reasoning in the selection of these standards. Actually, the specifications for a cottonseed flour with functionality should more nearly approximate the composition of the flours in table 1.

Table 1. Composition of defatted cottonseed flours

Composition (percent)	PAG guidelines	Glandless direct solvent	Glanded liquid cyclone
Moisture	10.0[1]	9.5	3.8
Crude fat	6.0[1]	2.4	1.2
Crude fiber	5.0[1]	3.3	2.3
Total gossypol	1.2[1]	.06	.06
Free gossypol	.06[1]	.04	.02
Free fatty acids (of oil)	1.8[1]		
Protein (N x 6.25)	50.0[2]	54.7	66.2
Available lysine g./16gN	3.6[2]	3.9	4.0
Nitrogen solubility	– –	95.7	99.6

[1] Maximum.

[2] Minimum.

Each specification bears some importance to the total acceptability of the flour. For most purposes, the crude fat content should be 1 percent or less. Lipids can contribute to off-flavors in the product through the production of fatty acids. Lipids can also contribute to the nonprotein contaminants of cottonseed isolates.

The crude-fiber content of a flour is very important to the mouth feel and texture of a product. Two types of particles, hull fragments and cell-wall fragments, are the major contributors to the crude-fiber content. However, this analysis will not always reflect the level at which these occur. Both the appearance and the crude-fiber content of the glandless flour prepared in Oklahoma (see table 1) would seem to be acceptable. However, if an aqueous suspension were prepared, the flour would be rejected for most food uses on the basis of hull content.

The gossypol contents of the two flours are similar. The small amount of gossypol in the glandless flour is probably due to the presence of a few glanded seed in the field-pollinated, glandless seed. The level in these flours, though quite low, could present a color problem for certain end uses. With time and storage of the flour, these pigments will impart a grayish-purple cast to aqueous extracts or dispersions, rather than the pale yellow color normally associated with gossypol.

The protein requirement for a flour will be dictated by the end use. The protein content of a cottonseed flour is determined by the degree of hull and lipid removal. A cottonseed flour containing 1-percent lipid and no hull will be approximately 60 percent protein on a dry-weight basis. Processes such as the liquid-cyclone process, which provide additional fractionation, will produce a flour that very nearly reaches the protein level of a concentrate.

The available lysine (12) and nitrogen solubility measurements (6) are normally used as guidelines to indicate the amount of heat denaturation which the flour has received. Denaturation with heat will affect, primarily, the aqueous solubility of the low-molecular-weight functional proteins of the seed. The importance of this denaturation will again be determined by the particular end use. The nitrogen solubility determination, as proposed by Lyman (6), for cottonseed meals, is far too rigorous for flours which have received only minor heat treatment. An extraction ratio of 1 gram of flour to 15 ml. of 0.027 N sodium hydroxide should be a more sensitive test for the nitrogen solubility of cottonseed flours.

It is also important to relate these various components of the composition to the particulates found in the cell of the cottonseed, for we are using the cellular particulates of the flour, not analyzing the simple constituents. The cell of the cottonseed, which is the oilseed processors' raw material, is composed of various particulates. The oil and storage proteins are deposited in discrete particles called spherosomes and protein bodies (17).

Each of these particles is surrounded by a distinct, but different, type of membrane. When the oil is extracted, the sphereosomes are emptied, but the membranes remain (5). Much of the residual lipid of the flour is associated with these residual spherosome membranes. As noted earlier, the crude-fiber analysis is associated with the cellwall fragments and the hull particles. The major part of the protein or nitrogen of the seed is associated with the protein bodies. These contain the storage proteins of the seed. These proteins are not water extractable. They represent 50 to 60 percent of the total nitrogen and are the predominant, high-molecular-weight proteins found in an isolate from the cottonseed (9).

The spherosomes and protein bodies of the cell are, in turn, embedded and surrounded by the base material of the cell called the cytoplasm, which contains various particles and enzymes to keep the cell alive and functioning. This part of the cell contains those proteins which serve some function other than storage in the cell. These functional proteins are water extractable and make up 25 to 30 percent of the nitrogen of the seed. They are a group of many different, low-molecular-weight proteins which are high in lysine and cystine. In the presence of steam, they are solubilized or hydrated, then heat denatured (precipitated) and can effectively glue the intact protein bodies in place. Under such conditions, the solubility of the protein body proteins is not significantly affected but the extractability can be decidedly reduced.

The effects of various operations on the cottonseed can best be understood, therefore, in terms of both the composition and the particulates involved. For example, the high nitrogen content of the liquid-cyclone flour (table 1) is due not only to the total removal of hull particles, but also to the preferential removal of the cell-wall fragments during the differential centrifugation. Consequently, the liquid-cyclone flour differs from the glandless flour not only in composition, but also in the relative proportion of the type of particulates involved.

Presently, there are three terms used by the industry to describe vegetable protein products; flours, concentrates, and isolates. These products are differentiated on the basis of protein content. Consequently, they differ also in nonprotein constituents. Flours, containing 50-percent protein or more, can be prepared by dehulling, defatting, and grinding. The preparation of concentrates, which contain a minimum of 70-percent protein on a dry-weight basis (DWB), requires further fractionation of the seed constituents. The raw material for the preparation of a concentrate is usually the defatted flour. However, the liquid-cyclone process, which produces a product of about 68-percent protein (DWB) from glanded seed, is an exception.

Concentrates can be prepared from glandless cottonseed by either dry or aqueous fractionation procedures. With a selectively ground, defatted meal, i.e., one that is not ground to a single particle size, the intact protein bodies can be concentrated at the expense of the cell-wall fragments by the dry operation of air classification (fig. 1). This process (11) can provide two products: one, the accepts or concentrate containing 70-percent protein (DWB); the other, the rejects or coarse faction. The latter, if prepared under sanitary conditions, can be either a food or a feed product. This closed, dry operation of air classification has very interesting advantages from the pollution aspect of processing.

Two aqueous extraction procedures can also be used to prepare concentrates from cottonseed (fig. 2). Extraction with aqueous ethanol (9) removes the extractable sugars, free amino acids, and residual lipids, as well as certain color and flavor components. However, no fractionation of the cellular proteins or particulates is produced. Because of the insolubility of the protein body proteins, a concentrate can also be produced by simple aqueous extraction, with or without .008M calcium chloride (7). (The calcium ion is thought to aid in the stabilization of the protein body membrane.) Successive extractions with dilute calcium chloride and water remove the low-molecular-weight, water-extractable proteins, in addition to the sugars, free amino acids and certain color and flavor components. Inherent in aqueous procedures,

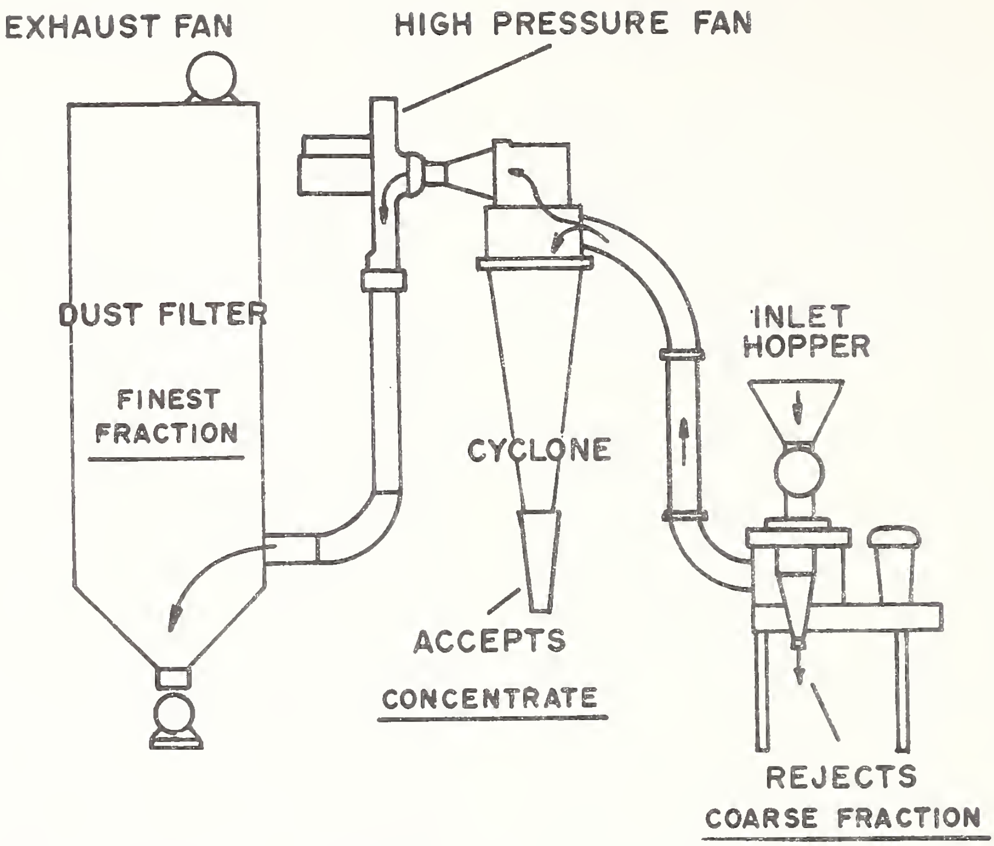

Figure 1. Diagram of the air classification process for the dry preparation of protein concentrates

however, are the problems of byproduct recovery and water pollution. The aqueous alcohol procedure also has the problem of alcohol recovery and denaturation of the concentrate.

The composition and yield of concentrates prepared by these various procedures are given in table 2. These concentrates differ in composition, particularly the crude fiber and total

Table 2. Composition and yield of cottonseed protein concentrates. Method of preparation.

Method	Air classification	Aqueous extraction: 90 percent ethanol	Aqueous extraction: .008 M $CaCl_2$ H_2O
Composition – percent [1]			
Protein (N x 6.25)	73.7	71.9	75.9
Lipid	.7	.1	2.6
Ash	9.4	8.7	8.5
Crude fiber	1.7	2.7	3.7
Total sugar (as invert)	4.7	2.1	.3
Yield[2]			
Percent of total weight	56	84	60
Percent of total nitrogen	63	93	77

[1] Dry-weight basis.

[2] "As is" basis.

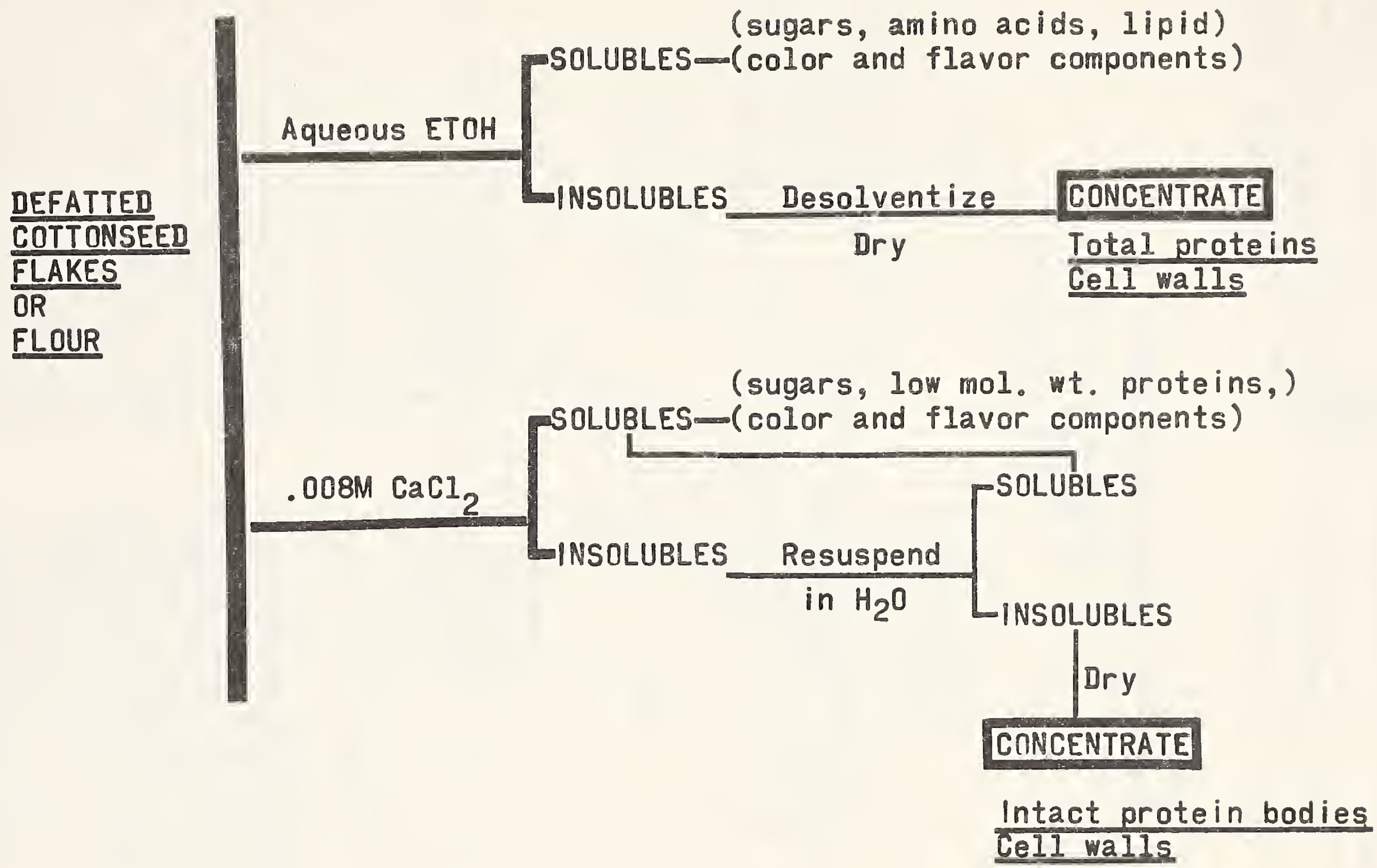

Figure 2. Flow diagram of aqueous extraction procedures for the preparation of cottonseed protein concentrates

contents, and in the type of particulates and proteins present. The air-classified concentrate contains both groups of proteins, but it is low in cell-wall fragments. The alcohol-extracted concentrate contains both groups of proteins and cell wall fragments, whereas the aqueous, salt-extracted concentrate contains only the cell-wall fragments and the protein body proteins as the intact protein bodies.

Different types of isolates can also be prepared from defatted cottonseed flour through a number of procedures. In the normal or what might be termed the classical procedure (fig. 3), the maximum amount of nitrogen is extracted with dilute alkali, followed by acidification of the centrifugal protein liquor at a pH value which provides maximum precipitation of the "proteins" (with cottonseed, pH 5) (3). The separated protein curd is then washed and dried, either at the pH of minimum solubility, pH 5, or at pH 7, as the sodium proteinate. Such an isolate contains both the functional proteins and the storage proteins of the seed.

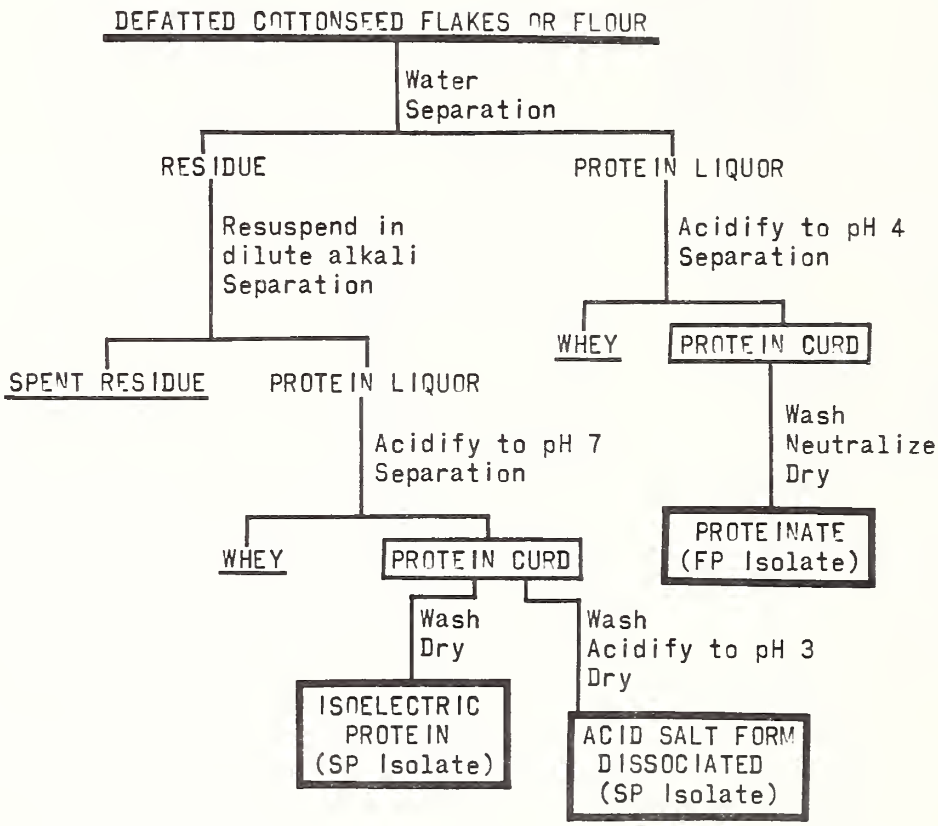

Figure 3. Flow diagram of classical procedure for the preparation of a single isolate from cottonseed

Based on the extractability characteristics of the cottonseed proteins, the two-step, selective extraction procedure was developed (fig. 4). In this procedure (2), the low molecular weight functional proteins are extracted first with water followed by reextraction of the residue with dilute alkali to remove the storage proteins. The protein liquors are then acidified to the appropriate pH (pH 4 and pH 7, respectively) and the protein curds are washed and dried at the desired pH. This procedure provides two isolates whose protein complement differ in molecular weight, amino acid composition, and solubility characteristics. These isolates also differ in solubility from the classical isolate. The solubility curves for the three isolates are given in figure 5. Note the unusual acid solubility of the storage protein isolate which is masked by the presence of the functional proteins in the classical isolate.

The functional and storage protein isolates can also be prepared by selective precipitation (fig. 6), i.e., maximum extraction with alkali followed by successive precipitation at pH 7 and pH 4. In addition, the storage protein isolate alone can be prepared by total extraction of the seed proteins with calcium chloride followed by

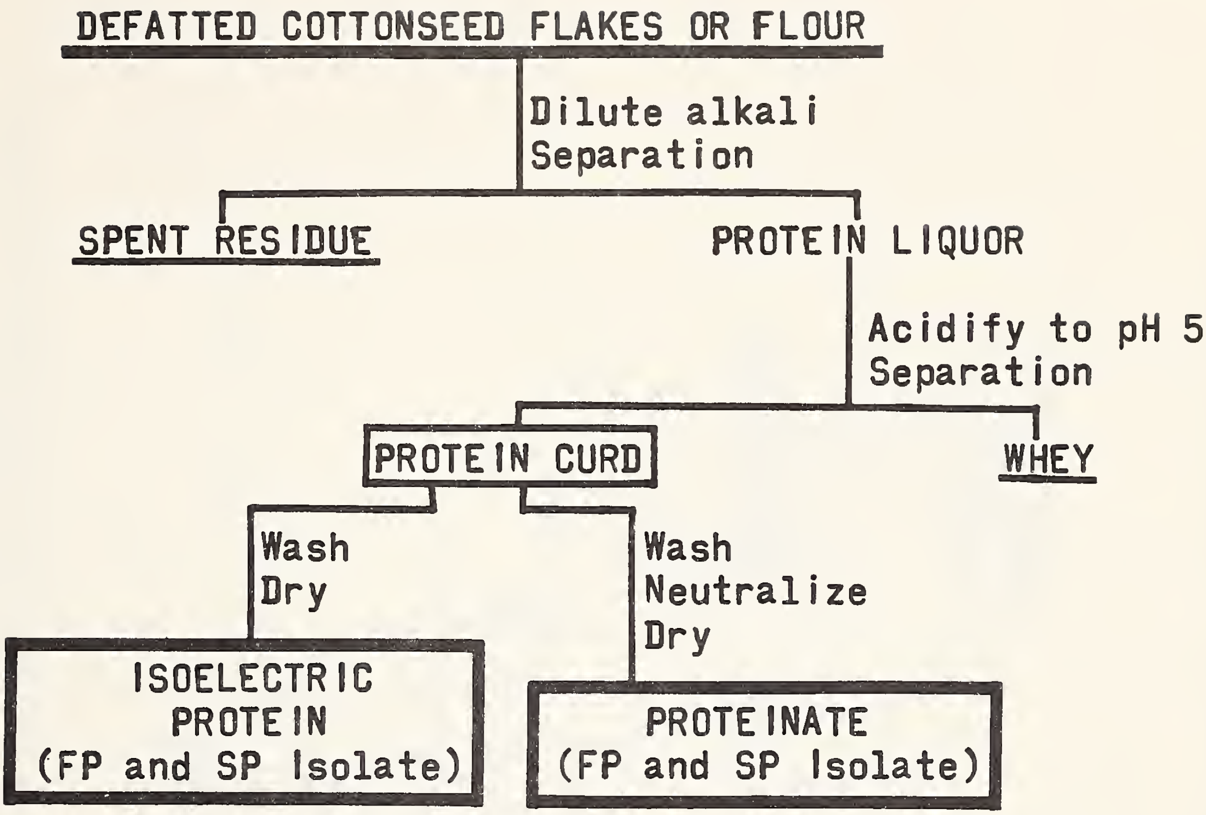

Figure 4. Flow diagram of two-step, selective extraction procedure for the preparation of cottonseed isolates

selective precipitation of the storage proteins as the acid dissociated, calcium complex at pH 3 (fig. 7). Each of these procedures and two additional variations (10) are presently being evaluated with both the glandless and liquid-cyclone flours. These procedures are also being evaluated on a pilot plant scale to determine the commercial adaptability, economic feasibility, and the associated microbiological and pollution problems.

The cottonseed, therefore, offers the potential of a variety of different types of concentrates and isolates. One might well ask at this point, why prepare concentrates and isolates? Why not simply prepare the flour? It is true that the glandless flour and the liquid-cyclone flour have many desirable characteristics. The flavor is bland and it has been reported that the flour will texturize to a very acceptable product. However, it is also true that no one protein produce will contain all the functional characteristics desired by the food industry. Indeed products within one particular protein level may differ in functional characteristics. For example, the unique and desirable acid solubility of the storage protein isolate is only apparent in the absence of the functional proteins of the seed. While the functional protein isolate is soluble at a pH, pH 7, which is the point of minimum solubility for the storage protein isolate. The storage protein isolate also functions very well in bread dough systems even at levels of substitution as high as 10- to 15-percent (8). But the functional protein isolate, with its high cystine content, interferes with the normal dough structure at a level of 3-percent.

A specific functional characteristic will vary with the protein, the nonprotein and the processing history of the product. Studies with cottonseed protein products on changes in the consistency of aqueous slurries with temperature

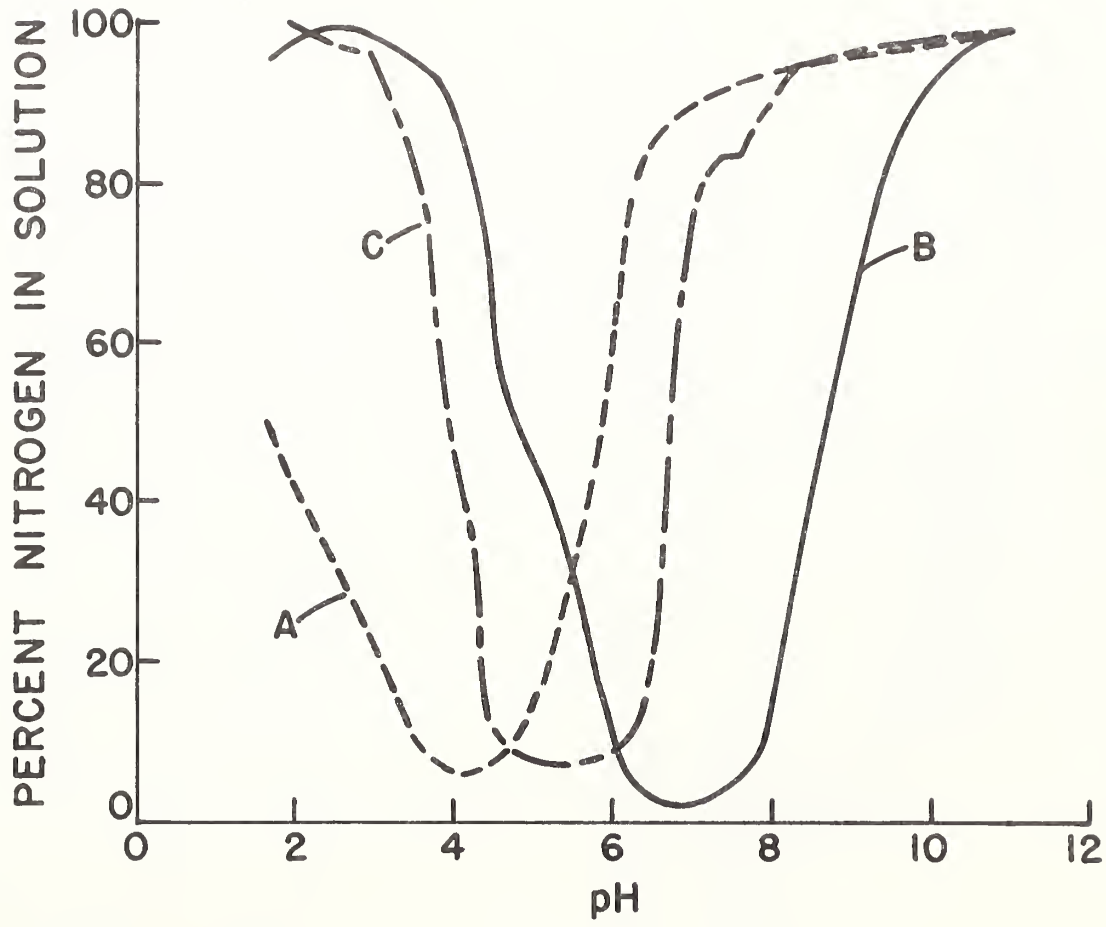

Figure 5. Nitrogen solubility curves of 1 percent solutions (pH 10.5) of isolates from the two-step and classical extraction procedures. Curve A — Functional protein (FP) isolate, two-step extraction; Curve B — Storage protein (SP) isolate, two-step extraction; Curve C — Classical isolate (FP and SP proteins), classical procedure. pH values taken after centrifugation

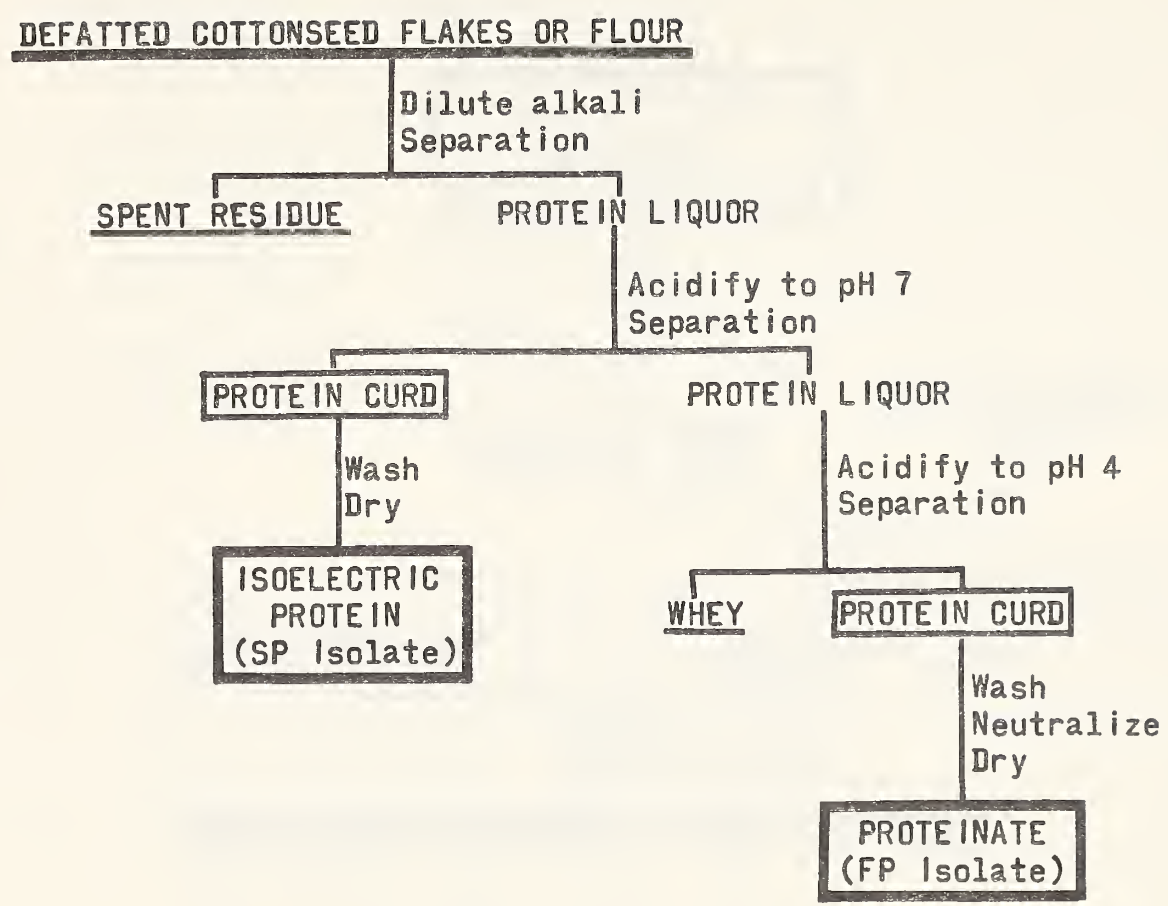

Figure 6. Flow diagram of selective precipitation procedure for the preparation of cottonseed isolates

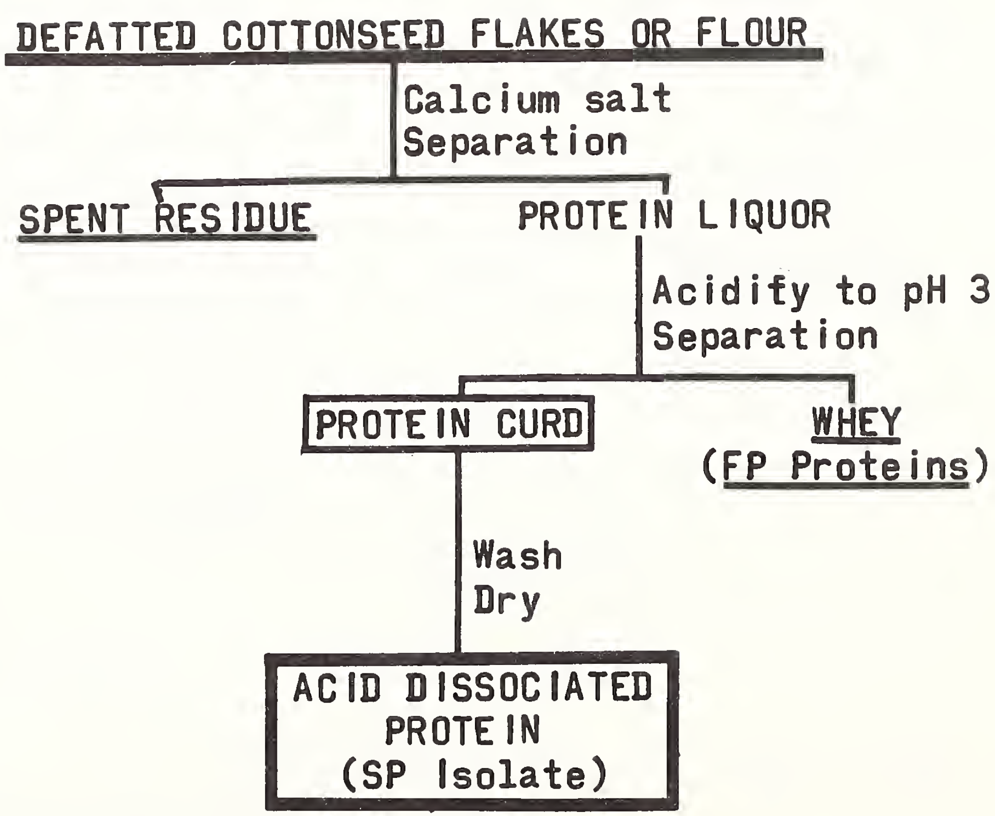

Figure 7. Flow diagram of total extraction and selective precipitation of the acid-dissociated, storage protein isolate as the calcium complex

have provided several illustrations of this fact (1). The consistency patterns of three flours dried to different levels of moisture are given in figure 8. The lower the moisture content of the flour, the lower the consistency. These results suggest that the hydration characteristics of a flour can be controlled by the desolventizing operation. The consistency of viscosity patterns of the air classified concentrate and the coarse fraction are given in figure 9. These patterns illustrate the importance of the various particulates in the product. The coarse fraction with its high concentration of cell wall fragments has a thick puddinglike consistency on heating. Whereas, the concentrate has a pattern which shows a sharp rise and decrease in consistency. This is due to the agglomeration of the intact protein bodies of the concentrate and the separation of the slurry into a two-phase system. The importance of the particulates in the product is also shown in figure 10. Here the two-phase consistency pattern of the air-classified concentrate differs sharply from the aqueous-extracted concentrates, which contain both protein bodies and cell wall fragments.

The cottonseed contains, therefore, the potential for the production of many different types of protein products which can provide many different types of functional characteristics. However, until the basic raw materials, the edible grade glandless and liquid-cyclone flours, are available, the preparation and desirable functional characteristics of the cottonseed protein products will remain a point of academic interest. The importance of the proper timing in this rapidly developing food protein ingredients market cannot be overemphasized or overstated. It is possible that in time, the unique characteristics of cottonseed products will be matched by other protein sources.

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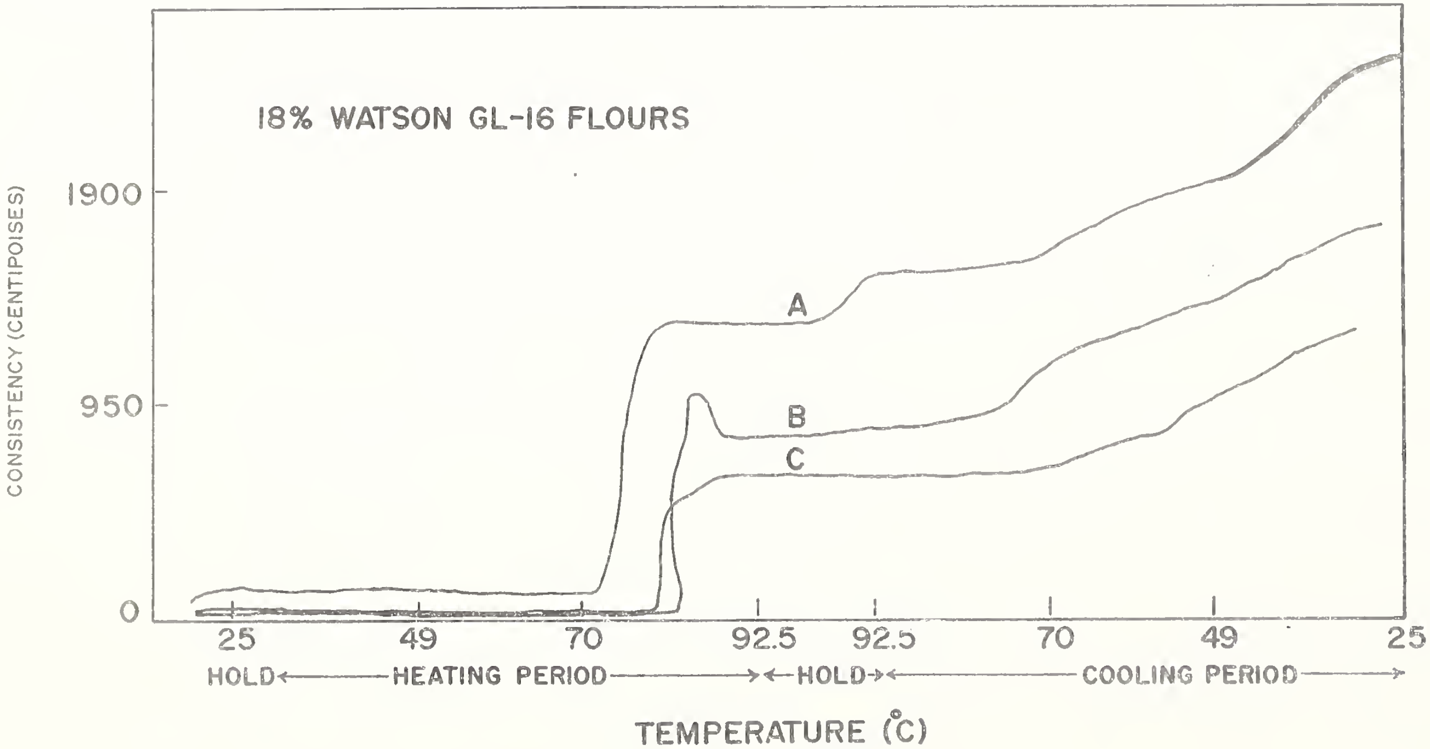

Figure 8. Brabender consistency patterns of aqueous slurries containing 18 percent Watson Gl-16 cottonseed flours. (A) Air dried; 11.5 percent moisture; (B) Semi-commercial preparation — desolventizer toaster unit, 7.5 percent moisture; (C) Pilot plant — Schneckens-type dryer, 4.4 percent moisture

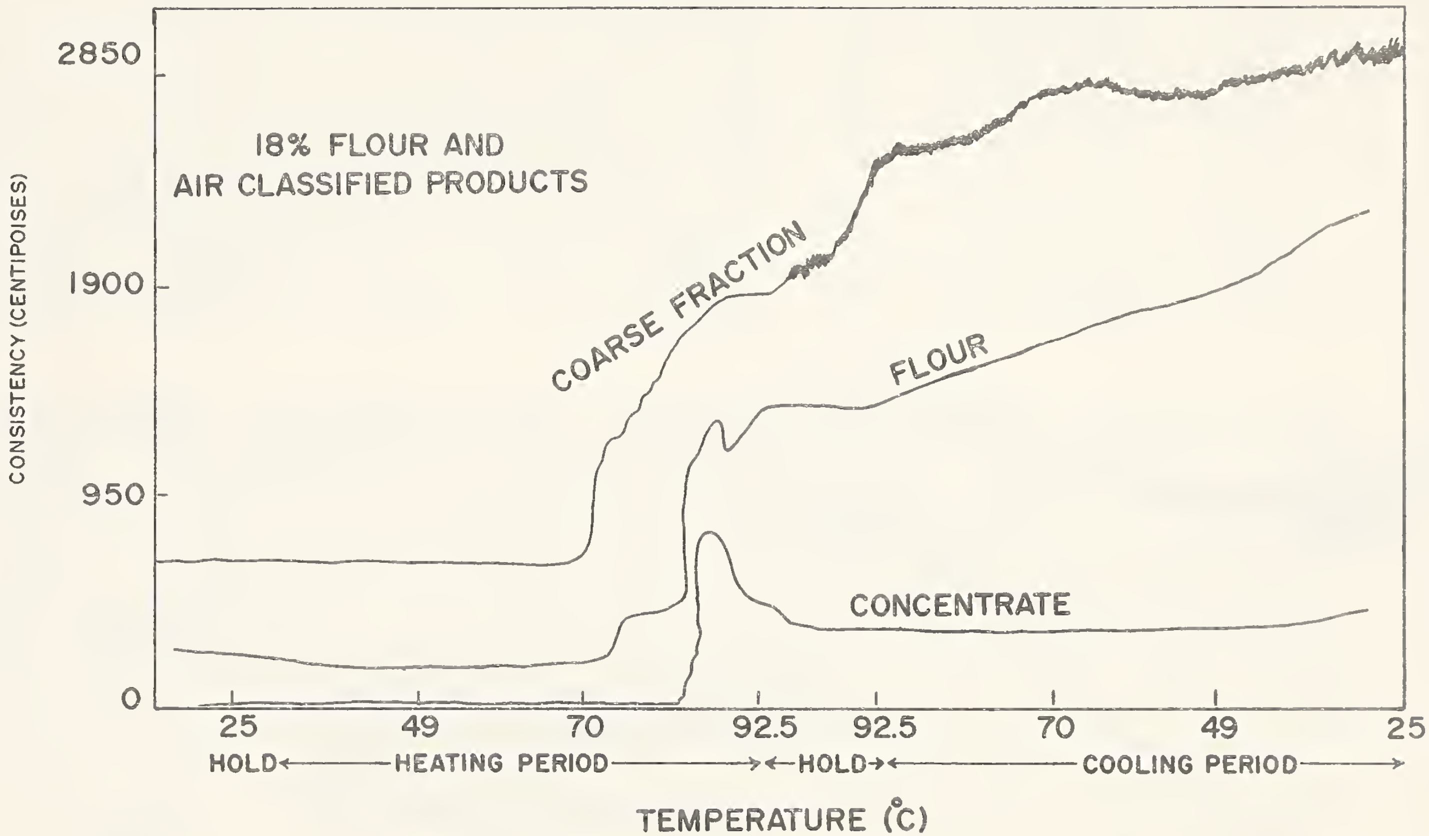

Figure 9. Brabender consistency patterns of aqueous slurries containing 18 percent Acala flour, the air-classified concentrate or the air classified coarse fraction

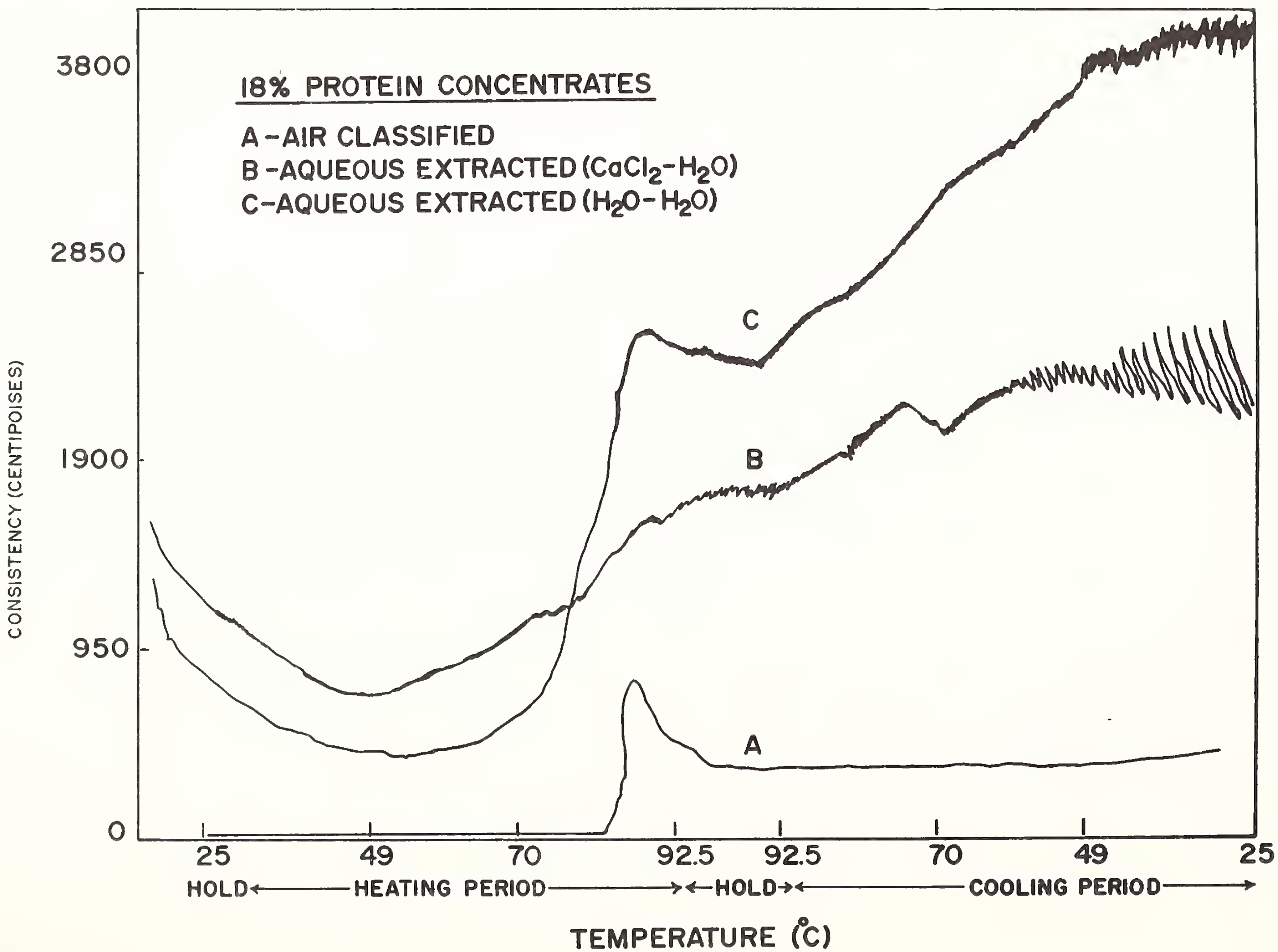

Figure 10. Brabender consistency patterns of aqueous slurries containing 18 percent: (A) Air-classified concentrate, (B) Aqueous salt extracted concentrate, (C) Aqueous extracted concentrate

PLANT AND PROCESSING REQUIREMENTS FOR NEW PRODUCTS FROM COTTONSEED MEALS

by
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(Presented by James J. Spadaro)

INTRODUCTION

Research has shown that high-protein products, such as flours, concentrates, and isolates, for use in food formulation and supplementation can be produced from either glanded or glandless cottonseed.

Today, oil mills processing cottonseed are not designed and operated to produce food-grade protein products. But, with some plant modifications, additional facilities and equipment, and the reorientation and training of management and operating personnel, these oil mills can be expanded to produce edible food products along with their traditional feed products.

The plant and processing requirements for each of the operations necessary for producing these new food products will be emphasized in this presentation.

Cottonseed. One of the important requirements is the procurement of good quality seed and maintenance of its good quality during storage. This seed must be free from aflatoxins and salmonellae, and during storage, protected from weather, insects, birds, and vermin. This will require the mills to maintain rigid control of the quality of incoming seed destined for food products, and this will no doubt demand increased laboratory control work and facilities.

Meats preparation. Results of work conducted by SMN and other organizations have shown that only whole and cracked meats will be suitable for production of food-grade products from either glanded or glandless cottonseed. The reasons for this are: 1) these meats can be prepared with very low hull and fiber content, which if present in the extracted meals and flours, are almost impossible to remove completely; 2) whole and cracked meats are lower in total bacteria count than either the original seed or the fine meats fraction, the latter containing high hull and fiber content; and 3) the lower bacteria count is necessary because of the minimal heat (kill steps) used in subsequent processing to produce end products with the desired nutritional and functional characteristics. Consequently, most oil mills will have to improve their hulling and purification operations in order to produce the whole and cracked meat fractions essentially free of hulls and lint.

Flour from glanded-cottonseed-liquid-cyclone process. In the case of glanded cottonseed processing, the whole and cracked meat fractions (blended) are conveyed to a meat drier to reduce their moisture content to below 3 percent. Lowering the moisture content of the meats toughens the pigment gland wall and minimizes gland rupture during subsequent milling. The dried meats are transported by an enclosed conveyor (to reduce moisture pickup) to the satellite facility.

Here, the following operations are carried out: rolling to a minimum thickness of 0.012 inch; mixing the rolled material with hexane to form a fluidized slurry containing about 45-percent solids; pumping the fluidized slurry through a stone mill (0.004-inch clearance between stones) to detach the meat tissue from the pigment glands; diluting the milled slurry with additional hexane to about 20-percent solids; pumping the diluted slurry under optimum pressure to a liquid cyclone (3-inch diameter) to separate two fractions — an overflow slurry fraction containing a fine, high-protein flour essentially free of gossypol, and an underflow fraction containing pigment glands, coarse meat particles, and full fragments.

The flour in the overflow fraction is recovered by filtration, washing to remove oil, desolventization, drying, and sterilization. The coarse underflow fraction may be recovered for use as feed by one of two methods: 1) by filtering and washing to remove the oil on a rotary-pan-type, horizontal vacuum filter, followed by desolventization in the parent plant desolventizer or 2) by returning it to the extraction unit of the parent plant, provided the quantity is sufficiently small not to create an imbalance in the extraction unit because of particle-size distribution.

As noted above, the main equipment units required for the satellite facility are meat dryer, flaking rolls, fluidizer, stone mill, dilution tank, liquid cyclone, rotary vacuum drum, and pan-type filters, desolventizer-sterilizer, slurry pumps, and housing necessary for a food processing-type installation. Also, suitable packaging equipment and storage facilities are required.

Since this is a food-processing operation, the satellite plant will necessarily have to be designed and engineered similarly to other food processing plants. For example, the pneumatic system required to transport the product from

the production area to the packaging and storage area will require filtered air, and must be engineered so that there is no dead space area where the meal product can hang up.

Since the flour produced by this process contains 68- to 70-percent protein, it is essentially a concentrate. Therefore, no additional equipment is required.

Flour from glandless cottonseed. Glandless cottonseed has been used experimentally to produce edible, high-protein products by several research-oriented organizations such as the Southern Regional Research Laboratory, The Oilseed Products Research Center at Texas A&M University, the National Cottonseed Products Association, and industry organizations such as Crown Iron Works and the Producers Cooperative Oil Mill at Oklahoma City, Okla.

Early work at the Southern Laboratory has shown that glandless cottonseed could be processed by conventional solvent extraction methods to produce a feed meal and a light-colored oil. The research work had also shown that processing modifications are required to produce a high-grade, high-protein soluble, light-colored meal suitable for preparation of nutritionally desirable, edible flour, concentrates, and isolates.

It has been mentioned that whole or cracked meats, essentiallly free of hulls and from good quality seed uncontaminated with aflatoxins, should be used. In addition, glandless seed should be moisture-conditioned so that the meats will have a moisture content of at least 9 percent prior to dehulling. This has two advantages: first, the yield of whole and cracked meats will be increased, and second, the moisture gives the flake the stability necessary to obtain an adequate percolation rate during solvent extraction. By flaking the meats to 0.012-inch thickness, flake stability and percolation rates are further improved.

Heat conditioning of the meats prior to flaking is not required, nor desired, because of possible deleterious effect on produce characteristics such as protein solubility and functional properties of the resulting meal product.

With these preparation conditions, good extraction rates were obtained in a semicontinuous, basket-type, pilot-plant solvent operation at the Southern Laboratory, and in continuous pilot-plant test runs at Crown Iron Works, Minneapolis, Minn.

Commercially, flakes are normally prepared at a location some distance away from the solvent-extraction plant. It is best to convey these flakes by means of an enclosed belt conveyor rather than a screw conveyor to minimize breakage of flakes. This minimizes the formation of fines. If the flakes are to be elevated, the use of a bucket-type elevator is prefered to a rotor lift.

For solvent extraction, normal temperature of about 140° F. can be used. Extraction units that result in minimization of fines are preferred. Because of the elimination of hulls and the omission of the meat-tempering step, extraction times may be increased, thereby reducing to some extent the normal plant capacity.

In addition, meal desolventization conditions must be modified in order to produce a light-colored meal. These modifications include low temperature desolventization, i.e., 140° to 155° F., in lieu of temperatures about 200°, elimination of steam sparging, and an increase in desolventization time.

The glandless cottonseed meal produced in accordance with the above conditions should result in a light-colored product, bland in flavor, containing about 60- to 63-percent protein (N x 6.25), a protein solubility of over 90 percent, low total bacteria count, good functional characteristics, and high nutritive value.

Three commercial scale tests have been carried out with glandless cottonseed. The meals produced from these trial runs have not been completely satisfactory, primarily because all of the processing modifications outlined above could not be incorporated because of limited scope of the test runs. However, in the latest run, carried out at Oklahoma City in the fall of 1969, it was shown that a light-colored meal with high-protein solubility could be produced commercially.

The meal contained an appreciable amount of hull and fiber, because plant modifications could not be made to exclude the use of the fine-meats fraction. Subsequent experimentation has shown that the hulls could not be completely removed from this meal or flour without greatly reducing the yield of acceptable product. Also, air classification tests to prepare a concentrate using meal produced from this run were not successful. This is believed to be due to subsequent treatment to which the meal was subjected.

The experience gained during the commercial test run emphasized the need for separate facilities for processing the whole and cracked-meat fractions to produce food-grade products and the fine-meat fraction for feed-grade products. The nature of the separate facilities depend upon the ratio of whole and cracked meats to fine meats obtainable. For example, with a 50:50 ratio, it may be desirable to have two separate solvent extraction facilities, whereas, with a 70:30 ratio of whole and cracked meats to fine meats, it may be desirable to have a screw-press operation for the fines fraction.

The mill that processes glandless cottonseed for food uses will, in all probability, want to produce the product as a flour. This will require

the installation of flour milling equipment which includes grinders, screens, classifiers, pneumatic transport system and other auxiliary equipment similar to that used in the flour industry. It must be stressed again that these operations be conducted in an improved, sanitary manner.

Air classification to produce protein concentrates. Meals produced from glandless cottonseed having an initial protein content of about 63 percent have been ground and air classified to produce a protein concentrate with 70-percent protein and with a 50-percent yield. In test runs, meals produced under ideal conditions at Southern Laboratory and Crown Iron Works were used. Protein concentrates have been produced using two different types of grinding and classifying equipment: (1) Alpine Kollopex stud-mill pulverizer and a Pillsbury air classifier; and (2) a combination Majac, particle against particle pulverizer-classifier unit.

Cottonseed protein isolate pilot plant. You have previously heard discussed the research being conducted on protein isolates from cottonseed. The Engineering and Development Laboratory has purchased the necessary equipment units, including stainless steel centrifuges, a spray drier, sanitary mixing tanks, piping and pumps, and other auxiliary equipment to erect a pilot plant to produce cottonseed-protein isolates. The plant is designed to produce about 50 pounds of protein isolates per day. Installation of the plant is scheduled for completion before the end of this year.

Sanitation. As in other food-type operations, sanitation and good manufacturing practices are of the utmost importance. In producing flour, concentrates, and isolates for human consumption, the oil mills will be dealing with more complex operations. Consequently, more rigid control over the entire operation must be maintained.

The oil mills of today are not equipped, nor are the personnel oriented toward the production of food products, other than oil. With the emphasis being placed on micro-organism contaminants in feed products, as well as in food products, it will be essential that mills entering the food field organize, install better control measures, and gear their thinking to the production of food products and processing conditions to meet the necessary sanitary requirements.

The whole and cracked meat fraction is appreciably lower in total bacteria count than the original seed. If care is taken in maintaining acceptable sanitary standards up to the desolventization operation, the desolventizing temperatures used, even though mild, will be sufficient to reduce the total bacteria count in the product to an acceptable level. Good sanitary practices are especially important following desolventization, since this is the last "kill step" in the overall process.

SUMMARY

This presentation has been a summarization of the changes in the plant and processing operations that are recommended for an oil mill interested in producing edible protein products from both glanded and glandless cottonseed.

Perhaps the two most significant requirements are: (1) That whole and cracked meats be processed in a separate or satellite facility; and (2) that sanitary conditions similar to those used in the food industry be maintained throughout the processing operations.

GLANDLESS BREEDING AND GLANDLESS COTTON PRODUCTION

by
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I want to briefly outline the broad steps or stages leading to crop improvement. First, we have the discovery of an economically valuable trait or characteristic. Second, we gain understanding of the inheritance or breeding behavior of this trait or characteristic through genetical research. Third, we have the actual applied breeding and selection. Fourth, we have variety evaluation and development. Fifth, merchandizing of the planting seed of the new variety begins, and finally, we achieve crop improvement when an economically significant acreage is planted to varieties with this trait or characteristic.

Breeders and seedsmen have separate functions in the evolution of crop improvement. The breeder conducts the research and development, while the seedsman's job is merchandising and sales of planting seed. It is important to bear in mind that the breeder and the seedsman have distinctly different roles in crop improvement. The breeder is a visionary with an eye constantly on the future — the present is past history to him; while the seedsman handles the business end of the seed trade — his eyes and ears are tuned to the here and now.

The farmer is the seedsman's customer. Likewise, the seedsman can be viewed as the breeder's customer.

The evolution of glandless cottonseed from

discovery to projected crop improvement reads as follows:

1954	Discovery
1954	Genetical research begins
1956 (majority in 1960)	Breeding and selection begins
1966	Evaluation and variety development begins
1966	Merchandizing begins
1971?	Crop improvement begins

The original sources of glandless genes were few in number, and all these genetic lines were miserable agronomically. In 1959, the great task of transferring these genes from the original sources into the wide range of commercial types of cottons was begun. Most commercial cotton breeders made their first crosses in Mexico during the winter of 1959-60.

It's hard to pinpoint the exact year, but by 1965, a large array of glandless germ plasm existed, and the gene transfer stage was coming to an end. Nevertheless, by 1967, when I became plant-breeding specialist for the National Cottonseed Products Association, I found that most breeders were not sufficiently aware of this wealth of glandless germ plasm and were still making glanded by glandless crosses to develop new breeding materials. I have rectified this and am proud to tell you that since 1967, breeders have been making full use of the available diversity in glandless germ plasm. Today, glandless by glandless crosses are frequent, if not commonplace.

The transfer stage has lasted a little longer than first anticipated. This is attributable to the reliance that most breeds placed in the Backcross breeding method, instead of making full use of existing glandless germ plasms. The Backcross breeding method was dropped in time, and the delay in glandless cotton development was not great. However, it could have been.

All stages in the evolution of glandless cottons, except crop improvement, have begun. Up to this time, we have witnessed the commercial production of two glandless cotton varieties and the release of a third glandless cotton variety for production in 1971. These varieties are 'Gregg 25V', 'Watson GL 16', and, the latest, 'Gregg 35W'. There is a good possibility that two additional glandless cottons will be released for commercial production in Texas this year. We should know something about these two additional releases very shortly.

Eighteen years have elapsed since the discovery of glandless cottonseed in 1954 to the 1971 season, when at least two and possibly four glandless varieties will be in commercial production. How does this record for glandless cotton evolution stack up in comparison to improvement records in other crops? We'll take a brief look at hybrid corn, hybrid grain sorghum, Mexican dwarf wheats, and high-oleic safflower.

Hybrid corn

1905	G. H. Shull's discovery of the hybrid nature of corn varieties, i.e., hybrid vigor.
1909	Shull published this discovery and emphasized that single-cross corn hybrids could increase yields by 30 percent or more. However, seed production on female inbred parents was too low to make single-cross hybrids attractive to seedsmen.
1917 to 1920	D. Jones published the double-cross technique for economical production of hybrid corn planting seed. This discovery heralded the beginning of hybrid corn production and the founding of many commercial corn breeding and seed companies.

Elapsed time from the discovery of hybrid vigor in corn to discovery of the double-cross technique, which made use of this hybrid vigor a practical reality, was 16 years. The length of time from discovery of the double-cross technique to first commercial planting of hybrid corn averaged 13 years. The cumulative elapsed time from Shull's original discovery to average date of first commercial planting of hybrid corn is 28 years. The development of glandless cotton has gone along like greased lightening by comparison!

However, we are far more capable of getting a job done today than folks were back then. Remember, there were no commercial corn breeders in existence before Donald Jones discovered the double-cross technique. But there was a great proliferation of commercial corn seed companies following Jones' discovery.

How long did it take to achieve corn improvement?

Year	Percent acreage planted by hybrid corn in the United States
1929	0 (or practically so)
1939	23
1949	78
1959	95

Thus, it took 20 years from Jones' discovery until approximately 75 percent of the U.S. corn acreage was planted with hybrid corn. The

farmer had a need for high yields. Indeed, the nation had a need for greater corn production during World War II, and the commercial breeder satisfied his customer, the seedsman, who in turn satisfied the farmer's demand for hybrid corn. Naturally, the farmer had a built-in preference for the higher yielding hybrid corn varieties over the lower yielding, open-pollinated corn varieties. It's easy to see why corn farmers needed and wanted hybrid corn.

Use of the cytoplasmic male-sterile technique in the production of hybrid corn planting seed eliminated the need for costly hand detasseling, and thus drastically reduced the cost of hybrid corn planting seed. Cytoplasmic male-sterile seed production techniques played a major role in the spread of hybrid corn production starting in the early 1950's. The nearly total reliance by the commercial seedsmen on a Texas source of cytoplasmic male sterility resulted in serious trouble in 1970, when it was discovered that this source of cytosplasmic male sterilty transmitted susceptibility to the Southern corn blight to its hybrids.

This winter, corn seedsmen made hybrid seed production plants in Latin America and Hawaii to provide the blight resistant hybrids so badly needed in areas of the Corn Belt where Southern corn blight is present. The seedsmen had to return to hand detasseling to produce this seed, because other sources of cytoplasmic male sterility have not been sufficiently "bred up" to replace the Texas source. At the moment, no one knows how long it will take to "breed up" new cytoplasmic male steriles. In the meantime, corn seedsmen rely upon the old hand-detasseling methods to produce hybrid corn planting seed.

The need for hybrid corns resistant to the Southern corn blight is great, and corn seedsmen are doing everything they can to supply the proper seed. Where genetic stocks, breeding, seed techniques, and knowledge and experience exist, almost instantaneous changes can be made, but only where a need is apparent and recognized can the seed trade be expected to move with such extraordinary speed. Grain sorghum is a good example of this.

Hybrid grain sorghum. Grain sorghum is a self-pollinating crop species, but the discovery of hybrid vigor for yield in grain sorghum offered the potential of greatly increased yields. These were eventually realized. The evolution of hybrid grain sorghum is as follows:

1921	Hybrid vigor in grain sorghum discovered.
1929	Genetic male sterility discovered.
1953	Cytoplasmic male sterility discovered.
1957	First commercial production of hybrid grain sorghums.

Total elapsed time for discovery of hybrid vigor to the commercialization of this phenomenon was 37 years. Development of glandless cotton looks pretty good by comparison. However, it took only 5 years from the discovery of cytoplasmic male sterility until hybrid grain sorghums were produced commercially. Seed of seven hybrid grain sorghum varieties were released in November 1956 for 1957 plantings. The 1957 grain production of grain sorghums was almost double that of 1956!

Note how rapidly hybrid grain sorghums became a reality once the cytoplasmic male sterile was found. Seedsmen were already established and knew how to manipulate the seed production machinery using cytoplasmic male sterility, but it took a little over 30 years to reach that point of expertise. And don't overlook the incentive offered by higher yields. The development of the famous Mexican dwarf wheats is another example of the farmer's need for higher yields.

Mexican dwarf wheats. The evolution of Mexican dwarf wheats is:

About 1947	Japanese dwarf 'Norin 10' wheat was introduced into U.S. breeding program.
1955	First crosses made in Mexico with wheats derived from 'Norin 10' crosses bred at Washington State University, Pullman.
1961	First of Mexican dwarf wheats grown commercially in Mexico.

It took 15 years from the time that 'Norin 10' was introduced until commercial planting of the first Mexican dwarf wheat variety. However, it took 7 years from the time that the first Mexican cross was made until commercial production in 1961. It took 7 years from first cross, using poor agronomic genetic material, until Mr. Gregg's glandless 'Gregg 25V' was planted commercially. That's another plus for glandless cotton. With an assist from the weather, 'Gregg 25V' just might have achieved a degree of success similar to that enjoyed by the Mexican dwarf wheats. Such was not the case, and it was a sad day for our side when cotton farmers in the Lubbock, Tex., area decided 'Gregg 25V' was unacceptable. The new wheats, on the other hand, met Mexico's urgent need to become self-sufficient in wheat production. Yield increases ranged from 20 to 30 percent over older varieties.

These examples in crop improvement stress the primary importance of satisfying the

farmers' needs. Unless the farmer plants the new seed, no possibility exists for the new plant type to have an impact on the improvement of that crop. Protein content of wheat can be increased by approrpriate fertilization. The flour millers desire wheats with higher protein content, but the economics have not justified the farmers' use of fertilizers. Thus, the wheat farmer will probably continue in his present ways, which brings us to my final example — one in which breeding has improved in the use of the agricultural product.

High oleic safflower. Safflower oil is distinctive among vegetable oils in that it is composed of 75- to 80-percent linoleic acid. A new type of safflower was found amongst the world collection of safflowers which had an oil composition of 60- to 80-percent oleic acid. Except for color and smell, it is the equivalent of olive oil. This safflower type was used in crosses to develop high-oleic varieties. The evolution of high-oleic safflower is as follows:

1957	Crosses with high oleic introduction made
1967	Certification of 'UC 1' variety of high oleic safflower

This took 11 years. Again we see that glandless cotton development has proceeded quite well in comparison, with this safflower innovation.

At the time 'UC 1' was released, it was expected that it would be grown in amounts sufficient to evaluate commercial interest in the new oil. If the commercial reception to the oil were good, 'UC 1' would probably be replaced by varieities with higher yields and higher oil contents. Commercial reception was excellent, and 'UC 1' has not been replaced. However, no production records are available by which to judge its acceptance among farmers.

You can judge for yourselves that glandless cotton development has not lagged behind improvements in other crops. Glandless cotton development has been at least as good as improvements in other crops and frequently superior to them. The release of three varieties, with two more waiting in the wings, in the short 12 years from the winter of 1959-60 to 1971, is an enviable record. Don't let anyone tell you otherwise.

We're going to have glandless cottonseed — the question is when. Most, but not all breeders are now in the testing and evaluation stage with their better glandless cottons. Of course, some breeders have been in this stage for the past several years, but now most are. The question immediately before us is will the seedsman — the business end of the seed trade — look favorably upon releasing these glandless cottons offered by the breeder. Individual mills can be of great assistance to these seedmen in making their "go-no-go" decisions by informing them how much they would appreciate crushing glandless cottonseed with its lighter-colored oil, gossypol-free meal, and freedom from all the processing hang-ups associated with gossypol.

But, the crucial question revolves around whether the farmer needs glandless cotton. Until we develop a suitable answer for the farmer, production of glandless cotton will falter and stumble. This is an especially difficult job when glandless cottons are first being introduced, as they are today. Thus, we appear to be at an impasse: glandless cottonseed product values await market value. The seedsman and his customer, the farmer, need more than our hopes and aspirations for glandless cotton.

Mr. Rogers of Rogers Delinted Cottonseed Company decided to break this "Mexican stand-off" by offering a contract to farmers for planting his 'Watson GL 16' glandless variety. Last year, the contract specified $20 per ton over oil mill price. Fifteen thousand acres were planted. The majority of farmers liked the cotton, and most intend to increase their acreage in 1971 — under the same contract terms.

Mr. Gregg of Gregg Seed Farms takes the point of view that since the economic value of glandless cottonseed products has not been established, he cannot sell his varieties on their glandlessness. Instead, he merchandizes them on their increased disease tolerance and earlier maturity. He did this on '25V' and is repeating it on '35W'.

No seedsman can sell his glandless cottons to farmers on the promise that sometime in the future cottonseed from such cottons will bring better prices. Of course, lint yield must be at least equal to that of glanded cottons. Still, the sooner actual cottonseed product values are determined, the sooner glandless cotton production will increase.

Bearing in mind that cottonseed is bought on the basis of seed grade, California excepted, I think we have prospects of offering some possible immediate benefits to the farmer who grows certain glandless cottons. Some glandless cottons produce seed with higher oil content, more protein, and lower free-fatty-acid buildup. The seed grade of such seed is greater relative to seed with lower oil, lower protein, or higher free fatty acids. By marketing glandless cotton varieties with such attributes, their higher seed grades would net the farmer more money for his glandless seed. This would tend to create a need to plant glandless cotton, while staying within existing trading procedures.

I have been working with breeders and seedsmen on this matter, and have urged them to run seed grade analyses of their glandless cottons. With such information, the seedsman

has some immediate merchandizing leverage. It's too early to say what effect I've had, but the discovery of additional high-oil glandless cottons is definitely encouraging. I will pursue this line of assistance with increased vigor.

Another development augers well for glandless cotton production. Last year, Plains Cooperative Oil Mill, Lubbock, Tex., announced that it was planning to construct a food plant for processing cottonseed protein. This proposed plant will have the capability of processing either glanded or glandless cottonseed and will put cottonseed protein into food trade channels for the first time.

Although most of this protein will of necessity be processed from glanded cottonseed, the markets tapped by this protein will pave the way for protein from glandless cottonseed. Not only will a food plant have been established which can process glandless cottonseed protein, but market opportunities will have also been opened up. The very existence of a food plant should greatly encourage the production of glandless cottons. Its proposed construction coincides perfectly with the impending release of more glandless cotton varieties in the Lubbock area.

I don't know the first thing about process engineering, but is it too far fetched to think that glandless cottonseed could be more economical to process through such a plant than glanded cottonseed? If it hasn't already been looked into, I would hope that some process engineering or operations research be devoted to this question. We know that glandless cottonseed, being free of gossypol, is easier to process, and processing requirements are less demanding than for glanded cottonseed. But if glandless cottonseed offers definite processing economies, it would be the preferred raw material and should compete with glanded cottonseed for such use in proportion to the economies involved. This says nothing about differential values for the products from the two types of seed.

In summary, crop improvement involves not only technical considerations, but economic ones as well. The seed business is a very competitive one. I have pointed out that while cotton breeders have accomplished a great deal in a comparatively short span of time by producing a wealth of glandless germ plasms, our problem today is to get the proven glandless cottons released as varieties and into production. This is a business decision for the seedsman, not the breeder, and such decisions are related to and dictated a good deal by the farmer's need to grow glandless cottons.

Until now, we have by necessity concerned ourselves mainly with the technical problems of breeding glandless cottons. Now we are at last coming face-to-face with the gutsy economic issues of what it takes to release a new cotton variety. The dilemma of which comes first, production or value, must be resolved. We are investigating ways and means of coping with this. The possibilities for encouraging glandless cotton production offered by glandless cottons with higher seed grades, and the establishment of a food plant for processing protein from cottonseed, look promising.

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STUDIES ON THE TECHNICAL AND ECONOMIC FEASIBILITY OF THE PRODUCTION OF LOW-FIBER COTTONSEED MEAL A PROGRESS REPORT

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During 1969, a research study was initiated in the Oilseed Products Research Center with these goals:

1. Development of methods for maximizing the production of large meats and hull particles, and concommitant minimization of production of small particles during hulling of cottonseed.
2. Maximum separation of hulls and linters fibers from meats.

These two objectives dovetail together, because achievement of the first automatically makes achievement of the second easier.

The purposes of this research were:

1. To increase the ease of making high protein-low fiber, glanded cottonseed meal.
2. To contribute to the know-how for making superior, low-fiber, glandless, cottonseed meal.
3. To develop procedures for preparing glandless kernels for use in human food. These kernels must be of maximum size and completely free of hulls.

This paper will review the justifications for this research and will report on progress and plans to date.

Low-fiber, glanded meal. — At several oilseed processing clinics in the past, notably those of 1966, 1967, and 1969, H. L. Wilcke, Garlon Harper, and R. V. Baumann discussed the probable future market demand for cottonseed meal (1, 2, 6). They pointed out that urea and ammonia are making inroads into traditional ruminant markets for cottonseed meal, because a mixture of urea and grain can replace up to one-third of the oilseed meal in a ruminant ration. The protein deficit of past years has been largely eliminated, and future increases in domestic consumption of oilseed proteins must come mainly from increases in animal numbers, rather than from increased feeding rates. The large production of soybean meal has enabled it to supplant cottonseed meal entirely in ruminant feeds in many areas where cottonseed meal formerly dominated the market. The speakers suggested that under these conditions, cottonseed meal should attempt to penetrate the market for nonruminant feeds.

One of the principal disadvantages that 41-percent protein cottonseed meal faces in competition with soybean meal is high, crude fiber content, which gives cottonseed meal a lower energy value. Crude fiber is largely indigestible by nonruminants, and thus it becomes merely a diluent of the feed. Consequently, cottonseed meal may be used only in small amounts for nonruminant feed, and then only if the price is considerably lower than the price of soybean meal.

H. L. Wilcke summed up his views on the subject in 1969 in these words. "If cottonseed meal is to compete for the poultry markets, and also for swine, we must have a glandless or low gossypol meal, low in fiber, preferably free, but certainly low in mycotoxins, and processed with a minimum of heat to provide maximum availability of amino acids." (7)

Some mills are presently producing CSM higher than 41-percent protein, and many more undoubtedly could do so if they wanted. However, the best ways to achieve more complete separation of meats and hulls are believed not to be generally known. Thus, one of the reasons for embarking on this research was to point out some ways to achieve better separation and to determine what losses of oil and protein in hulls are likely to result.

Glandless cottonseed meal. — Glandless cottonseed continues to demonstrate in feeding tests that it has great potential as an improved feedstuff for nonruminants. For example, in a recent study on egg production, the birds fed 100-percent glandless cottonseed meal laid

significantly more eggs on significantly less feed than the control soybean meal (5). The glandless meal used contained 53-percent protein and 4.5-percent crude fiber. The soybean meal contained 44-percent protein, and this meal usually contains close to 7.0-percent fiber. Because of the differences in protein level, the requirement for cottonseed meal was only 80 percent that of soy, the difference being made up with grain.

These results and others indicate that glandless cottonseed meal has the potential to compete on favorable terms with soybean meal, but the glandless meal will have to be low in crude fiber in order to reach its potential.

Food products from glandless cottonseed. About 1-year ago, scientists from the Oilseed Products Research Center presented the results of development work on "Tamunuts". These are glandless cottonseed kernels processed for direct human consumption (4). Much interest was generated by this report among food companies, and the principal factor holding back commercialization of Tamunut products at present appears to be the limited availability of raw material.

To make Tamunuts, glandless cottonseed kernels are needed which are nearly whole in size and are completely free of hulls. These are then subjected to electronic sorting to remove most of the contaminating glanded kernels, if any, and also any discolored kernels and unhulled seed.

Good hulling and separating procedures are essential for this work in order to give the maximum production of acceptable kernels from limited supplies of high-quality, glandless seed.

Other food products from glandless seed wil also either require low-hull kernels or will be at least benefitted by low-hull content in the raw meats.

Thus, research is needed on hulling and separating cottonseed for use in production of:

—low-fiber, glanded meal,

—low-fiber, glandless meal,

—and glandless kernels and flour for human food.

Survey of present practices and attitudes. Recently, representatives of five leading cottonseed crushers and a representative of the National Cottonseed Products Association were surveyed regarding their attitudes and practices on production of higher protein-lower fiber meal. The questions posed to them and their replies (slightly edited) are given below.

Question: Does your company sell cottonseed meal with guaranteed protein different from 41-percent? If so, list protein-fiber guarantees, selling prices, estimated tonnages in 1970, and process used.

Reply no.	Protein pct.	Fiber pct.	Price $/T	1970 tonnage	Process
1.	41	15	90	100T/D	Prepress-solvent
	44	12	95	300T/D	Prepress-solvent
	50	7	105	100T/D	Prepress-solvent
2.	41	15	85	65 percent	Prepress-solvent
	44	13	90	35 percent	
3.	41		85		
	48.5	10	98	10,000 T	Prepress-solvent
4.	41		Base		
	44	12	44/41 x base	None	—
	50	7.5	50/41 x base	None	—
	Higher protein meals are produced when higher revenues can be realized, when necessary to sell production, and when ammonia in seed is high enough to allow production to be maintained.				
5.	All production is 41-percent.				

Question: Do you believe markets can be developed for meal of higher protein than 41-percent?

1. Yes.

2. 44-percent meal is currently used in western poultry markets. There is also a small market for 50-percent protein.

3. Yes. Western meal is degossypolized and replaces soybean meal in poultry rations.

4. Yes — limited.

5. Yes, if a steady supply could be produced.

6. A market exists in the Far West. Elsewhere, the market depends upon relative prices of cottonseed and soybean meals, and opportunities are not great at present. In the future, the market for low protein meal will probably decrease.

Question: If you were going to attempt to market higher protein meal, what levels of protein-fiber would you seek?

1. Fiber as low as practicable. Experimental meals have been produced by screening which contained about 5-percent fiber.

2. 44-percent protein.

3. 44-percent protein, 11- to 12-percent fiber outside the West. 48.5-percent protein,

10-percent fiber (present production) in the West.

4. 50-percent protein, 7.5-percent fiber.
5. 44- to 50-percent protein.
6. 44- and 48- to 50-percent protein.

Question: Would you produce high-protein meal by removing hulls from meats during separation, or by grinding and screening extracted meal, or both?

1. Hull removal from meats is potentially the better way, however, we are presently screening extracted meal.
2. By separation of hulls from meats.
3. Both.
4. Both.
5. Do not know.
6. Largely by hulls-meats separation.

Question: Would you be able to produce these higher protein meals with ease or difficulty?

1. Such production is presently on a commercial scale.
2. 44-percent with ease, by separation.
3. Probably difficult with present equipment, in some areas.
4. Some difficulty. Needs high-ammonia seed, and separate storage of such seed is a problem.
5. Do not know.
6. 44-percent with ease. Higher percentages would require better separation or screening of meal.

Additional comment by No. 6: While technical problems are apparent for production of 48- to 50-percent meal, the situation is primarily of economic nature. Currently, the demand for 41-percent protein meal by the cattle and dairy industries is so strong that there is little opportunity to compete with soybean meal except in the West. There is reason to believe that this situation will change. I would now seriously consider developing knowledge how to produce high protein, low fiber, low, free gossypol meal for poultry and swine trade, and would introduce it as economics dictate. I would also prepare to produce an ammoniated meal-hulls product, equivalent in nitrogen to 41-percent protein with about three-fourths of the nitrogen coming from meal and the remainder from ammonia.

The consensus of these replies seems to be—

1. A limited market for higher protein meal exists in the West, and there is some production for this market.
2. Production of meal higher than 41-percent protein should be attempted by separation of hulls from meats, but this is not easy, particularly for protein levels approaching 50-percent.

These replies support the need for research on the hulling and separation operation.

Hull content and prices of meal. — While we are defining the problem, it will be instructive to look at figures on the hull content of meals of different protein and crude-fiber content, and the prices for which higher protein meal will have to sell to give the same return as 41-percent protein meal.

Soybean meal from 49- to 50-percent protein and 3-percent crude fiber is often held up as the product which cottonseed meal must match. If cottonseed meal is to contain only 3-percent crude fiber, it will be nearly hull-free and will normally be considerably higher than 50-percent protein. Hull-free meal will usually analyze between 2.0- and 2.5-percent fiber. Completely delinted hulls will analyze about 38-percent fiber, linters about 75-percent fiber. Hulls from seed with about 2.5-percent residual lint will analyze about 43 percent fiber.

Analyses were calculated for hull-free meal which theoretically could be made from two different lots of seed of differing nitrogen content. A value of 10-percent moisture and oil combined was chosen for the meals, so that they could be either screw press or solvent. The meats and meal analyses are shown in table 1.

Table 1. Analyses of hull-free meats and corresponding hull-free meals

Meats	1	2
Moisture	6.0	6.0
Oil	32.30	33.64
Protein	36.70	37.90
Protein, mofb[1]	59.49	62.79
Meal		
Moisture[2]	10.00	10.00
Oil[2]		
Protein	53.54	56.51

[1] "Mofb" is moisture and oil-free basis.

[2] Combined moisture and oil assumed to be 10 percent.

The quantities of the hull-free meals which could be mixed with hulls to make meals of differing protein content were then calculated. The hulls were assumed to contain nitrogen equivalent to 3.0-percent protein. Resulting crude fiber in commercial meal based on 2.2-percent fiber in hull-free meal and 43-percent in hulls were also calculated. The results of these calculations are shown in table 2.

The prices of higher protein meals were calculated using the proportions of meal and hulls in table 2, hull prices of $10 and $30 per ton, and a price of $80 per ton for 41-percent protein meal. These values were used to

Table 2. Proportions of hull-free meals and hulls to make 100 pounds of commercial meals of designated protein levels

Hull-free meal, percent protein		53.54	
Commercial meal, percent protein	41	44	50
Hull-free meal, pounds	75.2	81.1	93.0
Hulls, pounds	24.8	18.9	7.0
Crude fiber in commercial meal, percent	12.3	9.9	5.1
Hull-free meal and hulls in meal of 3-percent fiber, pounds		98.1 and 1.9	
Protein in 3-percent fiber meal, per cent		52.57	
Hull-free meal, percent protein		56.51	
Hull-free meal, pounds	71.0	76.6	87.8
Hulls, pounds	29.0	23.4	12.2
Crude fiber in commercial meal, per cent	14.0	11.7	7.2
Hull-free meal and hulls in meal of 3 percent fiber, pounds		98.1 and 1.9	
Protein in 3-percent fiber meal, percent		55.49	

calculate prices for hull-free meals of the two protein contents, and these prices were used for the meal fractions in the various mixtures. The results are shown in table 3. Prices in the last column on the right were calculated using protein ratios times price of 41-percent protein meal.

Table 3. Calculated prices of higher protein cottonseed meals

Material	Protein	Price per ton		Price by ratio[1]
	Pct	Dollars		
Hulls		10	30	
Hull-free meal	53.54	103.10	96.50	
Hull-free meal	56.51	108.60	100.40	
Commercial mixtures	41	80.00	80.00	80.00
	44	85.50	84.00	85.85
	50	96.60	91.80	97.60

[1] Price = percent protein/41 x price 41 percent meal.

The data of table 1 demonstrate the effect that seed analysis has on the protein content of the resulting meal. Expressing the protein in meats on a moisture and oil-free basis gives a useful index to predict the protein content to expect in meal.

The data in table 2 show that even 50-percent protein meals will contain considerable quantities of hulls which will result in fiber contents well above 3-percent. If 3-percent fiber meal is produced, it will be nearly hull free.

The data in table 3 show that higher protein meals must sell for considerably higher prices than 41-percent meal, and the price of hulls is an important pricing factor if equal return is desired for all levels of protein in meal.

Using ratios of protein in meal to calculate prices of higher protein meals is nearly equivalent to assuming a zero value for hulls. However, meal is purchased by users for its protein content, and theoretically, it should be priced strictly on this basis. If it is priced this way, sale of the hulls that have been removed to raise the protein ratio will provide an additional monetary return.

Review of accomplishments and current status. — Unpublished, small-scale dehulling experi-

ments conducted in our laboratory in 1969 demonstrated that the proportion of coarse kernels in the meats was increased considerably if dry seed were moistened and equilibrated to about 10.5 percent moisture before hulling. This work was conducted on delinted seed of about 2.5 percent residual lint. Moistening to higher levels had some further benefit, but it was not great.

Lawhon demonstrated that live steam treatment of unmoistened, dry seed produced about the same results as those from moistened equilibrated seed (3). Steam treatment gave better quality meats for human food and eliminated the need for storage of seed after moistening to achieve equilibration of moisture.

This work was conducted to increase the yields of coarse, glandless kernels for use in food products. However, the results are applicable to hulling for any purpose, such as improving separation of hulls and meats for manufacture of higher protein meals.

Presently, the Levelland Vegetable Oil Co. in Levelland, Tex, is installing equipment to process glandless cottonseed for food uses at a rate of about 2 tons per hour. The steaming procedures advocated by Mr. Lawhon will be used in an Anderson 36-inch horizontal conditioner.

Woolrich described a similar procedure in 1939, (8) and I am sure other people have used live steam treatment of seed before the huller, but their work has not been described in print.

In 1970, we installed the following new equipment in our laboratory specifically for experimentation on hulling and separating. This machinery was manufactured by Carver Cotton Gin Co. and comprises:

1) A 24-inch-wide, Perfection huller mounted over a

2) 36-inch-wide, two tray, purifying-type, shaker separator,

3) a 36-inch-wide, meats purifier,

4) a 48-inch-wide, hull and seed separator,

5) a single-drum, hull beater,

6) a single-drum, tailings beater.

Using this machinery, we intend to measure the effects of at least the most important variables in hulling and separating cottonseed. Quantitative measurements will be made to enable us to calculate economic effects on oil mill operation, in terms of changes in quality of meal, increase or decrease in losses, increase in hull yield, etc.

We recognize the following as potentially important variables for the hulling operation.

Factors which may influence performance of a huller:

1. Seed Characteristics:

a. Genetic characteristics, such as thickness of hull,

b. degree of maturity,

c. range of sizes,

d. moisture content,

e. linters content,

f. other pretreatment of seed.

2. Huller characteristics (for Carver huller):

a. Clearance between cylinder and concave,

b. speed,

c. number of knives in concave,

d. sharpness of knives.

3. Uniformity of feed and feed rate.

For any one lot of seed, most of the seed characteristics in the list will be constant. We have been measuring hull thickness and seed size, but we have not been attempting to size the seed, so far. Delinting has been conducted to about 2.5 percent residual.

No pretreatment has been conducted, except moistening to about 10.5 percent and equilibration for 48 hours before hulling. We realize that an oil mill would have difficulty holding seed for 48 hours after moistening. However, we have not wanted to introduce a potential source of variability and difficulty of control (such as steaming) to process which already has a considerable amount of variability in it.

From among the other variables, we plan to investigate huller settings (which will affect recycle rate), feed rate to the huller, huller speed, and perhaps number of knives in the huller concave.

So far, experiments have been preliminary in nature to establish sampling procedures, to learn how to operate the machinery, and to decide how to conduct the experiments. An important aspect of this has been measurement of normal variation with all controllable variables fixed. After the preliminary work is completed, the design for the main experiment will be constructed for statistical analysis of results.

Our long range plans include similar investigation of hulling sunflower seed. They also include investigation of other makes of hullers and other means of separation, such as perhaps air classifiers and gravity tables.

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INDUSTRY OPPORTUNITIES IN COTTON FLOTE AND FIRE-RETARDANT COTTON BATTING

by
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I am delighted to be able to discuss with you some ideas that might mean greater profits to members of both National Cotton Batting Institute (NCBI) and the Mississippi Valley Oilseed Processors Association.

When I received a copy of the printed program, I was interested to see that the conference theme is "After 20 Years--The Next Decade of Progress." I checked on the consumption of linters for the major felting markets over the past 20 years, and in doing, found the key to my own topic which, as the program states, is entitled "Industry Opportunities in Cotton-Flote and Fire-Retardant Cotton Batting."

First, I discovered by looking into past consumption figures of cotton linters by the automotive, mattress, and furniture industries that since there were no mill-waste figures available, this does not represent cotton-batting consumption, but only linters consumption. However, I think that this would be closer to your interests, anyway.

In 1951, 20 years ago, these three markets--automotive, mattresses, and furniture--consumed 264 million pounds of linters, according to statistics of the National Cotton Council.

In 1969, the latest year available, these same markets consumed 267 million pounds . . . so in linters we're just barely doing better than holding our own in a rising economy and with an expanding population. Moreover, 10 years ago, in 1961, consumption amounted to 363 million pounds . . . or, roughly 96 million pounds more than was consumed 20 years ago, or is being consumed today.

Such a decline could be construed that cotton batting represents an aging and shrinking industry. But the industries served by cotton batting do not show any such signs. On the contrary, they have enjoyed healthy growth during the past 20 years.

For instance, in 1951, the total of all cushioning material (including urethane, latex, and synthetic fiber fillings) used in the automotive, bedding, and furniture industries represented in terms of cotton equivalents more than 700 million pounds of cotton batting . . . and note here that I am talking about cotton batting, including linters.

In 1961, this figure had grown to almost 772 million pounds, and by 1969 to 930 million pounds. Obviously, cotton batting serves expanding industries. In 1969, when total cushioning materials consumed amounted to the equivalent of 930 million pounds, cotton batting's share of this amounted to 583 million pounds, or 62 percent of the total.

Now, when I think of industry opportunities or potential, I like to think of the potential as everything you don't have . . . so by this definition, cotton batting has a potential for growing by 347 million pounds, or 38 percent, annually. What part, if any, of this potential will be realized? Naturally, one cannot venture to predict.

The potential is there, and we believe that flame-retardant cotton batting and cotton flote offer two outstanding opportunities for realizing part of this potential. I believe that this is true, because both cotton flote and fire-resistant cotton batting represent superior products, offering superior benefits.

In these times, American marketers have developed what a recent magazine article referred to as their own version of Russian roulette . . . that is, they introduce new products. Despite the deadly risk, industry must develop and introduce new products or decay. That's the name of the dangerous game.

The alert and modern businessman realizes that in today's business world, he must obsolete his own products before someone or something else does. To stay in the competitive battle, more and more companies are expanding their research and development programs to find new products and are upgrading their marketing departments to sell them.

Granted, there are risks, but there is almost certain decay if the risks aren't taken. In fact, 2 or 3 years ago, figures were published which showed that business spent half a billion dollars to launch 6,500 new products, and 80 to 90 percent of them failed in the market place. That's a high casualty rate. It only proves what George Bernard Shaw said, that "Success covers a multitude of blunders."

The products that went under failed for a variety of reason, and we won't attempt to discuss them here. That is a problem that must be faced by individual companies and not by an industry organization. However, an industry organization can help in the development of new products, and that is exactly what the National Cotton Batting Institute, in cooperation with other trade groups and the U.S. Department of Agriculture, succeeded in doing with cotton

flote and a system of fire-retarding cotton batting.

It might, therefore, be of interest to you gentlemen to take a brief look at the organization so largely responsible for these products, and to look especially at how the new developments came into being.

The National Cotton Batting Institute, or NCBI, was organized in 1954 with the help of the National Cotton Council, when leading members of the batting industry realized that competitive materials were making serious inroads into cushioning markets which were traditionally cotton. Membership in NCBI is composed of dealers in linters and cotton-mill waste, and leading firms that manufacture batting and felt. The goal of the Batting Institute is to increase the consumption of cotton batting in bedding, furniture, automobiles, and other cotton-cushioned products.

The companies which make up NCBI membership are small when compared with the competition . . . giant chemical companies supporting the urethane foam industry, big rubber companies engaged in making latex foam rubber, and the textile greats which produce synthetic fiber fillings.

When viewed against this background, the industry really has done a remarkable job of maintaining cotton's market against competitors who, for years, have outspent and outreached cotton with tremendous sums of money.

NCBI had been in existence several years when it became apparent to many that cotton batting needed a new product, one that met the more sophisticated needs and demands of its cutomers, rather than the same garnetted product that daddy and grand-daddy had made. It is so easy and comfortable to do business at the old stand, in the time-honored way, and to follow the old maxim of "let well enough alone."

Cotton has certain inherent qualities that make it superior to the competition, but the competition has strengths, too. I think we must admit, for example, that the competion gives us a run for our money from the standpoint of the esthetic look and ease of handling. Anyway, to improve our product, NCBI undertook its first research program with the substantial help of the USDA.

I might observe here that it's been said that there are three superior ways to lose money. Of these, the most certain is agriculture, the most entertaining is women, and the fastest is to do research. We'll go along with the part about women. But though we were in agriculture and did do research, we didn't lose money. Rather, in a relatively short time, our research effort produced a new, chemically-treated, cotton-batting material, trademarked as "Cotton Flote."

"Flote" exhibits a high degree of dimensional stability, and can be die-cut to shape and size. "Flote" demonstrates rapid and nearly complete recovery from deformation under diverse environmental conditions, including temperature and humidity. Energy absorption characteristics are much improved, and tensile and tear strength greatly increased. "Flote" is truly one of cotton's outstanding research success stories.

As exciting an accomplishment as cotton flote was, however, we must admit that it has yet to realize its full potential. Originally, its first acceptance was by companies supplying auto makers, and it still is being used by that market, but not in the amount we hoped it would. I believe a check now would show that American Motors uses cotton flote in practically all its models, and that General Motors uses some, but not as much as it did even a year ago. Ford, the first in Detroit to use flote, still employs it in some light densities.

The fact of the matter is that the whole situation in the automotive market has become unsettled by a General Motors decision of about 18 months ago to phase out cotton from its entire line. According to NCBI automotive suppliers, this decision was not made not because of any shortcoming of cotton or cotton flote. Actually, I am told that GM's Engineering Division prefers cotton cushioning to urethane, its replacement. But the decision for change came from the top.

Top management, for one thing, apparently wants the image of a modern scientifically made cushioning material but, more importantly, it wants the saving which it contends is realized through the use of a slab of urethane, requiring no hand labor. Despite this setback, companies making cotton flote view its future with optimism. In fact, a pioneer company in the manufacture of flote is in the process of installing its thrid flote line. The material is being used by furniture makers for padding sofa arms and decks, chair seats, and insulation skirts. It is found in some mattresses and box springs in place of traditional insulating materials and conventional cotton cushioning. It also has been used in packaging applications for fragile materials.

The companies that indicated an interest in the material are legion and represent some of the leading firms in the country, including Boeing Aircraft, which was especially interested in fire-retardant cotton flote.

It is with fire retardance that cotton batting may find its most promising future. The time is not far distant when many articles of home furnishings and most, if not all, of the automobile's interior must be made of fire-resistant materials. We have every reason to believe that

cotton batting now has an edge on the competition when it comes to being made resistant to fire.

We know now that cotton batting can be made highly flame resistant . . . in fact, given almost a zero burn rate. we hear many rumors about what the competition can do, but for want of any hard fact, we must conclude that we are ahead of them in the state of our art. Our treatment actually improves some of cotton batting's characteristics, whereas one of the problems that urethane and foam rubber — our biggest threats — must solve is how to produce a fire-resistant product without affecting their cushioning characteristics.

Development of the USDA-NCBI system for impregnating and drying cotton batting rawstock for flame resistance is well under way. At Lummus Industries, Inc., in Columbus, Ga., a full-scale prototype treatment line is being set up to prove out the system and to prove out cost figures.

It is anticipated that the system will cost between $40,000 to $50,000 in a size capable of processing from 4,000 to 6,000 pounds of rawstock per hour.

Here, again, with fire-resistant cotton batting, as with cotton flote, it is obvious that there are opportunities for the batting industry. Whether they will be realized again becomes the question. Here, again, it is a situation calling for tough decisions and for taking risks. But, if you wish to stay in business, someone must take these risks . . . after all, most don't lose at Russian roulette.

There are plusses in favor of the batting industry when you talk about accepting hazards and introducing new products, certainly as compared with some industries. For one thing, the batting manufacturer is limited to a few channels of distribution.

Look at what faces some companies. For example, if your channel of distribution is through a discount house, your product is one of 70,000; if it is through a drug chain, it is one of 25,000; and if it is through a supermarket, it is one of 7,500 other products. So, as the old story goes . . . it could be worse.

Now, I know it's easy for me to stand up here and spout a lot of platitudes about how risks must be taken and opportunities met. None of my capital is on the line. I don't have to worry about the day-to-day operation of a batting plant. I don't have to struggle with union contract, meet payrolls, and on, and on, and on. Nor do I have to cope with a frequently changing market for cotton linters and waste.

I don't mean that any of my remarks should be taken to imply that the problems ahead are ones in which I am an expert or that can be easily solved. They are complex problems, as are so many in today's world.

It reminds me of the story of the woman who went into a toy store to buy a toy for a young child. When the clerk showed her the toy she finally chose to buy, she said, "Isn't this rather complex for a child of four?" and he said, "Oh don't worry about that, madam, this toy is designed to accustom the child to living in the world today. No matter how he puts it together, it's wrong."

Well, we hope we're not putting things together wrong, and we don't believe we are. From the vantage point of our industry-wide position, I think it's fair to say that in NCBI, we do get a type of overview of the entire market that gives us a different perspective. It is our job to try and translate the broader picture into specific benefits for the individual members.

This can best be done, I believe, by doing what NCBI has done and is doing. By taking the lead in the development of new products, our members can make a stronger case to their customers and can create a favorable atmosphere in which selling becomes more effective.

We do this latter through a continuing program of advertising and publicity that reaches users of cotton batting through a wide range of trade channels and reaches the consuming public through magazines, newspapers, radio, and television. But that is another story which there's not time to develop here.

Concluding, I believe that it is pertinent to say that despite the difficulties facing the batting industry and the problems involved in realizing the potential for cotton flote and fire-retardant cotton batting, the industry faces the future with a sense of resolve.

I believe that, given adequate quantities of raw materials at competitive prices, the cotton batting industry in the next two decades can remain healthy and resilient... by working together, adjusting to changes, and continuing to sell the superior qualities of its products.

A prosperity beyond anything we have had before is available to us. If we fail, the failure will be due to ourselves and not to our lack of opportunity.

SUMMARY

by
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Briefly, let us look back at the things that we said last year on this occasion. At that time, we speculated that conditions might be ready for cotton offtake to begin to improve, since it had been declining. I think that we commented at the time, though, that synthetic fibers had barely been able to keep cotton from growing. It appears now, referring to figures used at the National Cotton Council meeting in Dallas, Tex., this past week, that cotton has improved its offtake and market share in some interesting areas and may, in fact, be turning around. Had I known last year the severe slump that the whole textile industry would experience, I certainly would not have predicted that cotton's offtake would improve. However, it has improved despite the slump, and that's especially encouraging.

Also, we mentioned last year that the economics of fibers competing with cotton had eroded, and that much of the fun simply has to be gone in trying to take cotton's markets. Confirmation has come this past year. Two plants making man-made fibers that compete with cotton have either closed or have announced closing during this past year because of unattractive economic conditions. Conditions have undoubtedly been worsened by the textile slump and probably by pollution-control requirements. Nevertheless, I think that these closing confirm that competing with cotton under today's conditions is a tough game.

We also mentioned with regard to the protein and human food probabilities of cottonseed meals that the industry was saying, "Either put up or shut up" about this protein business. The papers that we have heard this afternoon have been especially encouraging, because they show that the oilseed industry is going to answer the challenge. Technology is coming along, and with this report of capacity and the nature of products, I think that it is apparent that the industry is positioning itself to "put up" rather than "shut up".

I hope that nobody here has interpreted the fact that we could not get an answer to the question of W. F. Wilkens' about the availability of these kinds of seed flours or proteins at $300 a ton as an indication of lack of interest. I think that it is simply a case of these products being entirely different from commodity cottonseed meal. They are products requiring a capital expenditure, and most people in this group have not come to the point of making an economic evaluation. They simply do not feel capable at this time of answering that question. I think that one of the jobs this industry has to do in the very near future is supply the answer to that question.

We also said last year that it was impossible to summarize meetings that are as packed full of information as these.

That is certainly true again this year! However, I would like to mention a few points with respect to some of the papers presented.

First of all, in Mr. Wooters' talk, one certainly gets the feeling that the fiber industries that hoped to put cotton out of business have missed their chance. I am especially impressed by the broad and solid foundation that we appear to be laying for the expansion of the cotton business. They are going about this thing in a thorough way, starting with a support in programs designed to get more economic production of cotton. If we can do that, the industry can protect itself in the profit and loss category and guarantee its survival.

There are also designing optimum fabric constructions. They are being realistic about certain performance advantages of the synthetics, and they are using these to help sell cotton. They are cooperating with the woolen industry to the advantage of both industries and the consumer. They are preparing, long-range, for the needs of the nonwoven market, which is predicted to be truly monumental in the future. Now, whether that is going to develop as fast as they say and be as large as they say, I don't know. But, if it is coming and is going to be as big as they say, then cotton has to have a very substantial place in that market.

Of special interest to this group were his remarks about developing a strain of glandless seed with a short fiber for the nonwoven market. This variety might be a 50-percent seed-50-percent fiber crop. They are looking at this for its economic advantage to the grower, as he stressed, but it would have tremendous economic implications for the cottonseed industry as well.

Dick Phelps has listed a number of questions that need answering. It seems that every time we do work on these pertinent questions, in addition to answering them, we often turn up three or four more. This is well demonstrated in the case of the aflatoxins, where in studying one, we have discovered a dozen more in the last 3 years.

I think this points up a problem for this

industry in its research and development program. In view of the rapid rate of development, I wonder if we devote enough attention to the setting of research and development priorities. It would appear that we can no longer afford to study and learn all the things we would like to know. At the present rate of change, it appears that we can barely afford to seek and learn those things that we have to know to meet the challenges of this industry. I wonder then if we are doing all we can and all we should to properly set the long-range research objectives, or should we call a national "huddle" of interested facets of the industry to help clarify the most pressing long-range needs of this industry. Perhaps this would be an appropriate discussion area for next year's clinic.

I think the record of the Agricultural Research Service and its accomplishments show that we can learn through research those things which we do have to know and that the primary problem is selecting the most important area of the study.

With regard to Dr. Fulmer's presentation on the potential of oilseed, I thought he did an excellent job of reviewing the history and projecting the potential of this industry. Such attempts to look into the future are indispensable in positioning the industry to meet the challenge of the future. However, it was the review of the history of this industry that impressed me the most. Growth has been nothing less than phenomenal. What a job has been done for the people of the entire world!

While Dr. Fulmer reports that meat is a relatively expensive source of protein today, can you imagine what the cost of meat would have been had this industry not grown and positioned itself to supply the protein which has supported the one-thousandfold expansion in broiler production and other meat product expansions?

The single-cell protein that he mentioned may be the protein of the future, but we owe much of our well-being today to this industry and to present protein sources. Who is to say that a substantial portion of the future market doesn't belong to proteins from cottonseed and soybean meal used as isolates or as direct additions to the human food?

Certainly, Margarette Harden's cookies and the brittle convincingly demonstrate that the problems of taste have been largely overcome. Reports by Mrs. Martinez and Mr. Spadaro indicate that process technology sufficient to meet these needs already exists.

As we continue in the direction of upgrading cottonseed and cottonseed meal toward the human market, seed quality becomes increasingly important. This has been stressed by a number of our speakers. Because of this, I wonder if the quality of the seed currently produced might not be an appropriate area for this group, or a committee of this group, to direct its attention. If some such group could design purchasing and testing procedures that could function properly in the highly competitive, seed-purchasing market, such a basis could improve the quality of seed. It could promote the proper handling of the seed and stimulate, on the part of seed suppliers, a quality consciousness that is going to be extremely important when we move into human-food processes. It seems that in some way we have to make a beginning, to prepare ourselves, on the basis of today's operations, to meet the needs of the food-supplying operation of the future.

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